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CLASS-BOOK

OF

PHYSIOLOGY;

FOR THE USE OF

SCHOOLS AND FAMILIES.

COMPRISING

THE STRUCTURE AND FUNCTIONS OF THE ORGANS OF MAN,

Illustrated by

COMPARATIVE REFERENCE TO THOSE OF INFERIOR ANIMALS.

By B. N. COMINGS, M.D.,

AUTHOR OF PRINCIPLES OF PHYSIOLOGY, PRESERVATION OF HEALTH, AND PROFESSOR OF PHYSIOLOGY, CHEMISTRY, AND NATURAL HISTORY IN CONNECTICUT NORMAL SCHOOL.

WITH TWENTY-FOUR PLATES, AND NUMEROUS ENGRAVINGS ON WOOD, COMPRISING IN ALL ABOVE TWO HUNDRED FIGURES.

SECOND EDITION,

WITH AN APPENDIX.

MEMPHIS, TENN.:
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1860.

PREFACE.

THE "*Principles of Physiology*," which has been so highly commended by all literary men, who have examined its merits, although well adapted to more advanced institutions, has been thought too large and expensive for the major portion of our schools. To meet the demand for a lower priced book, and comply with the desires of numerous friends of education, the Class-Book of Physiology is now offered to the public.

The unanimous verdict of teachers in favor of the general plan of the "Principles of Physiology," has induced the author to pursue the same method of illustration, and, if possible, bring to a higher perfection the original plan of that work. It has been his constant study in this treatise to explain and illustrate to the student, fully and clearly, as many of the most practical principles of Physiology, as could be included in the moderate limits of the present volume.

That Human Physiology can be made more easy of comprehension—more profitable, and more attractive to the young, by appropriate references to the Comparative Physiology of the inferior animals, than by any other method—is an established fact in the mind of the author, though he must leave it for others to judge of the success with which this plan has been developed.

Physiology owes much of its present eminence, as a deeply interesting and progressive science, to observations made on the structure and functions of the same organs in the lower orders of animals as are found to exist in man. Take from Human Physiology the light derived from Comparative Physiology, and it would become what it was centuries ago, an obscure and comparatively uninteresting science.

The young universally feel a deep interest in the animated beings which they see around them. The horse, the ox, the dog, and birds and insects, are all objects of admiration and wonder to the philosophic mind of youth; and when they learn that each possesses organs approximating more or less in structure to their own, their sympathies are enlisted, they feel a deeper interest in their own organization, acquire more noble and exalted views of the position they occupy in the scale of being, and learn to appreciate more truly the evidences of an all-wise design in the works of their Creator.

PHYSIOLOGY cannot but be considered, by every intelligent and reflecting mind, a deeply interesting and practically important study. It makes us acquainted with the structure and uses of the organs of life, and the laws by which they may be preserved in health and vigor. When a knowledge of the principles of Physiology shall be diffused through all classes of society, the sum-total of human happiness will be greatly increased, and more permanent enjoyment of health, and more exalted exercise of all the physical and intellectual powers, will be secured to each individual.

This science has peculiar claims to the attention of every teacher who would be successful in his profession. It presents, in their true light, those facts which lie at the foundation of mental development, and suggests the best means of promoting intellectual growth.

An appendix embracing various topics pertaining to health has been added to this edition, in the hope of making it of more practical value, and of greater interest to both teachers and pupils.

For the convenience of those who have not had sufficient experience to dispense with questions, they have been put at the foot of each page, and at the close of the appendix; but there is left ample scope for teachers to propose many more. For those who may be advanced in study, or who may review the book, a description of the figures and plates are recommended as a useful exercise.

Carpenter, Roget, Wilson, Pereira, Bourgery, Aitken, Kirkes and Paget, Horner, Hassall, Agassiz, Wyman, Chambers, Griscom, and various other authors, have been consulted in the preparation of this work.

The author is under obligations to the publisher of "*Principles of Physiology*" for permission to use the figures and such portions of the text of that work as he found suited to his purpose.

New Britain, July, 1854.

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CLASS-BOOK OF PHYSIOLOGY.

INTRODUCTION.

1. All bodies in which evidence of life has been observed, possess certain parts or organs, which are essential to the existence of the individual. A plant or an animal exists by means of its appropriate organs, and the matter of which they are composed is therefore called organized or *organic matter*.

2. Minerals exhibit no signs of life, but they continue to exist without any distinction of parts or organs, and belong to the kingdom of unorganized or *inorganic matter*. A piece of quartz, for instance, may be broken into any number of fragments, each of which will retain all the characteristics of the original mass.

3. Minerals may grow or increase in size by the superaddition of new particles to their surface; but they are not nourished, like organized beings, by interposing new particles between those which already form their substance.

4. In plants and animals, each part is essential to the completeness of the individual being, and no part or organ can maintain an independent existence. If a rose be cut from its stem, or an arm be amputated from the body, it immediately dies, and loses its original characteristics.

5. A plant is dependent upon its roots and its leaves for vitality, and an animal cannot live without its heart, its lungs, and its stomach.

What are essential to the existence of all living bodies? What is the matter of which such bodies are composed called? What is the matter found in minerals called? Do minerals grow? How? Are they nourished? What is essential to the completeness of a plant or animal? Can any organ maintain an independent existence? Upon what parts is a plant dependent for its vitality? Upon what parts is an animal dependent?

6. There are two conditions in which we may study organized matter: namely, as living beings and as dead bodies.

7. The science of *Physiology* is derived from the first method, and the science of *Anatomy* from the second.

8. Physiology makes us acquainted with the uses to which the different parts are subservient, and the laws by which they are governed.

9. Anatomy teaches the number, size, situation, form, texture, and composition of the various parts, with their relations to each other.

10. Anatomy and Physiology, in their most extended use, apply to all organized beings, though they are naturally divided into the several branches of VEGETABLE *Anatomy and Physiology*, and ANIMAL *Anatomy and Physiology.*

11. Animal Anatomy and Physiology are again divided into *Comparative* Anatomy and Physiology, and *Human* Anatomy and Physiology.

12. Comparative Anatomy and Physiology are devoted to the lower orders of animals.

13. Human Anatomy and Physiology are limited in their application to man.

14. The divisions of Physiology into *Comparative* and *Human* are usually made as a matter of convenience in study, and not because the Physiology of man is peculiar to him alone: for the same organs which exist in man, may be found in greater or less perfection in nearly all the lower orders of organized beings.

15. Comparative and Human Physiology naturally illustrate each other, and thereby become more interesting and more easily comprehended.

In what conditions may we study organized matter? What science is derived from the first, and what from the second method? With what does Physiology make us acquainted? What does Anatomy teach? How are Anatomy and Physiology naturally divided? How are animal Anatomy and Physiology divided? To what orders of animals are Comparative Anatomy and Physiology devoted? Why is Physiology divided into Comparative and Human?

PLATE I.

COMPARATIVE VIEW OF THE ORGANS OF CIRCULATION.

FIGURE 1.——*Circulation in the Insect.—a*, The dorsal vessel, divided into valvular partitions, by the successive contraction of which, the blood is propelled forward. *b*, *b*, Canals which carry the blood to the head. *c*, *c*, Canals passing backward for the supply of the body, and returning the blood to the posterior end of the dorsal vessel.—The course of the circulation is indicated by the direction of the arrows.

FIGURE 2.——*Circulating Apparatus of the Lobster.*—In the lobster and crab, the heart has but a single cavity, and the veins are indistinct, consisting merely of irregular channels excavated in the tissues. *a*, The heart; *b*, *c*, Arteries which go to the head and to the *antennæ* or feelers; *d*, The hepatic artery, or artery of the liver; *e*, *f*, Arteries which supply the thorax and abdomen.——After the blood has been propelled through these arteries by the heart, it passes into the great vein, *g*, *g*, from all parts of the body. Thence it passes to the gills, *h*, where it is exposed to the action of the air, and is then returned to the heart by the branchial veins, *i*, which correspond to the pulmonary veins of Man.

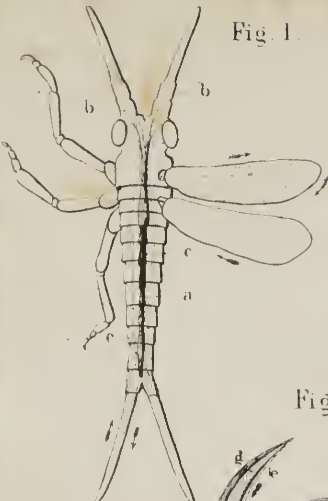
FIGURE 3.——*Sectional View of the Circulating Apparatus of the Lobster.—a*, The heart. *b*, *b*, Venous sinuses. *c*, *c*, Branchial arteries. *d*, *d*, The gills or branchiæ. *e*, *e*, Branchial veins, terminating in the heart.

FIGURE 4.——*Circulating Apparatus of Fish.—a*, The auricle, having a single cavity to which the blood is sent from all parts of the body. *b*, The ventricle, which receives the blood from the auricle, and propels it to the arterial bulb, *c*, into the branchial artery, *d*. The branchial artery is sub-divided into the arteries of the gills, *e*, in which the blood is aerated. *f*, *f*, The dorsal artery, or aorta, which receives the aerated blood from the gills, and distributes it to all parts of the body. *g*, The vena cava, or great hollow vein, which conveys the blood back again to the auricle. *h*, Vena portæ, that branch of the vena cava which conveys the blood from the abdominal organs. *i*, The intestine. *k*, The kidneys.

FIGURE 5.——*Circulating Apparatus of Lizard.—a*, Left auricle. *b*, Right auricle.—One of these receives the venous blood from the system, and the other receives the arterialized blood from the lungs. *c*, The single ventricle, which receives the blood from both auricles, and transmits it partly into the lungs and partly into the aorta. *d*, *d*, Arches of the aorta. *e*, Carotid artery, which distributes the blood to the head. *f*, Pulmonary vein, which conveys the blood from the lungs to the heart. *g*, Brachial artery, which goes to the fore-legs. *h*, *h*, Pulmonary artery, in which the blood is submitted to the influence of air in the lungs. *i*, The lungs. *j*, The stomach. *k*, Vena portæ. *l*, Intestines. *m*. Ventral aorta, or that portion of the aorta contained in the abdomen. *n*, Kidneys. *o*, Liver and vena portæ. *p*, Inferior vena cava, which conveys the blood from all the lower parts of the body to the heart. *q*, Superior vena cava, through which the blood of the upper parts of the body is sent to the heart.

FIGURE 6.——*Heart of Tortoise.—a*, Right auricle. *b*, Single Ventricle. *c*, Left auricle. *d*, *d*, Pulmonary artery. *e*, *e*, Pulmonary vein. *f*, Vena cava. *g*, Right aorta. *h*. Left aorta.

Fig. 1.



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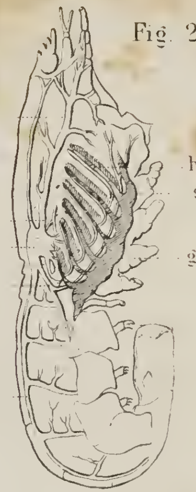

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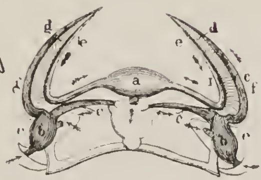
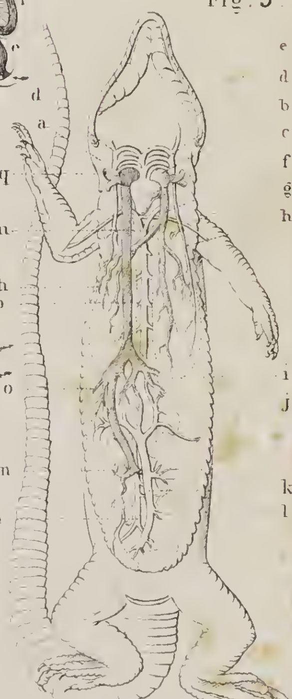


Fig. 4.

Fig. 5.



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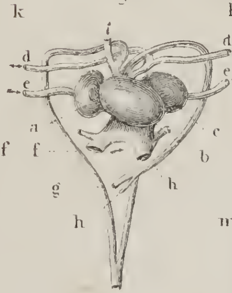


F. C. Kellogg, Lith.

CHAPTER I.

CHARACTERISTICS OF PLANTS AND ANIMALS.

16. Plants and animals are distinguished from all unorganized bodies by the process of nutrition and the property of rēproducing their kind. Plants are nourished by the inorganic elements found in the earth and air around them. The materials of their growth are received in the form of a liquid or a gas, already prepared for their use.

17. Animals are nourished by the organic materials of vegetables or of other animals. Animals always possess a stomach or a digestive cavity, in which their food is received, to undergo a process of preparation before it can be absorbed into their tissues.

18. Sensation and voluntary motion are peculiar to animals alone, and are therefore called animal functions.

19. Plants and animals both have a limited period of existence, which varies with every species. In some, this period is confined to a single day; in many plants, to a single summer: while some animals live more than a century, and some trees—as the oak and olive—are supposed to live a thousand years.

20. The natural age of man is usually estimated at about seventy years, though instances occasionally occur of individuals who survive an hundred or more years. The duration of man's life is less uniform than that of any other class of animals. In some communities, the average age at death is only ten or twelve years; in others, it is nearly forty. In all cases, individuals and communities are long-lived just in proportion as their localities, occu-

How are plants and animals distinguished from unorganized bodies? How are plants nourished? How are animals nourished? What do animals always possess? What functions are peculiar to animals alone? What is said of the period of existence of plants and animals? What is the natural age of man? How does it vary in different communities? In proportion to what are communities and individuals long-lived?

pations, and habits of life are favorable to health; for health and life are blessings lent to man only as conditions of obedience to the laws of his organization.

PLATE II.

GENERAL VIEW OF THE CIRCULATING APPARATUS OF MAN.

THE course and relative positions of the principal arteries and veins of the Systemic circulation are shown in this plate. The arteries commence from the great arterial trunk called the aorta, and their branches are distributed to all parts of the system. The venous branches, which accompany the arteries, unite into two great veins, the superior and inferior vena cava, which convey the blood back to the heart.

a, The left ventricle of the heart. *b*, The right auricle. *c*, The superior vena cava. *d*, The root of the pulmonary artery. *e*, *e*, The aorta, which is seen arching backward over the heart, and passing downward into the abdomen, where it divides into its two great branches, the iliac arteries, through which the blood passes to the lower extremities. *f*, The inferior vena cava, which accompanies the descending aorta and its branches, and returns the blood from the lower extremities. The dotted lines represent the outlines of the kidneys.

PRINCIPAL DIVISIONS OF THE AORTA AND VENA CAVA.

It should be remembered that most of the branches which spring from the great artery and vein, are double—that is, each right branch has a corresponding one at the left side—so that there are, for instance, the right and the left carotid arteries, the right and the left jugular veins, &c.

From the arch of the aorta are sent off those arteries which are distributed to the head and arms. The principal ones among these are named as follows:

g, The carotid artery, which ascends in the side of the neck, and divides into the temporal artery, *h*, which is distributed in the temple, and the facial artery, *i*, which supplies the face; and also sends a branch, called the internal carotid, to the parts within the skull.

j, The sub-clavian artery, lying beneath the clavicle or collar-bone. That part of the continuation of this artery which passes through the axilla or arm-pit, is called the axillary artery, *k*; that which lies in the upper arm, the brachial artery, *l*; and in the fore-arm, it divides into the radial and ulnar arteries, *m*, *n*, which are distributed to the hand and fingers in the manner indicated in the plate.

The principal branches of the descending aorta are named as follows.

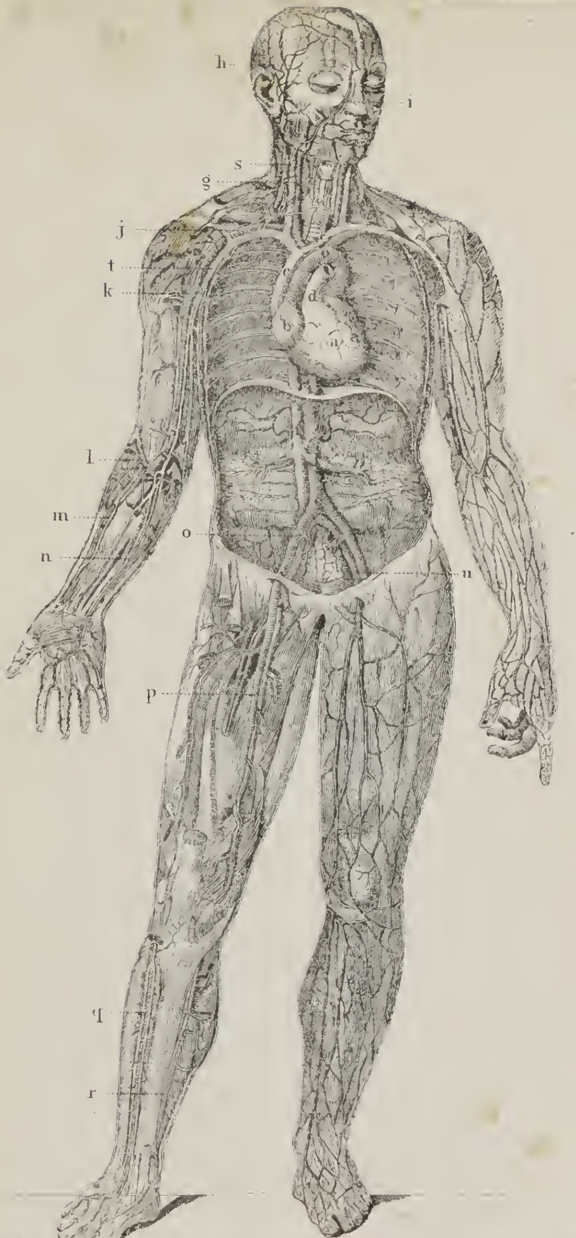
The iliac artery, *o*, which, on passing into the thigh, becomes the femoral artery, *p*, and in the leg divides into the tibial and peroneal arteries, *q*, *r*, which form numerous branches for the supply of the leg and foot.

Before dividing into the iliac arteries, the descending aorta gives off several important branches; as the cœliac artery, from which the stomach and liver are supplied; the renal artery, which goes to the kidneys, and the mesenteric artery, to the intestines; besides many other sub-divisions in various parts of its course.

The branches of the vena cava generally accompany those of the aorta in their distribution, as shown in the figure, and are often called by the same names. The principal divisions of the superior vena cava are:—The jugular vein, *s*, which accompanies the carotid artery. The sub-clavian vein, *t*, which accompanies the artery of the same name, and receives the blood from the arm and hand.

The inferior vena cava, like the aorta, divides into two great branches, the iliac veins, *u*, the sub-divisions of which accompany those of the arteries, and are called by the same names. The manner in which the superficial veins ramify and anastomose with each other is shown on the upper and lower extremity of the left side.

PL. II



CHAPTER II.

STRUCTURE AND COMPOSITION OF ANIMAL BODIES.

21. The component substances of animal bodies may be divided into fluids and solids:

22. The *fluids* are found mostly in the form of chyme, chyle, lymph, and blood. About thirty pounds of fluid can be drawn directly from a man who weighs one hundred and fifty pounds. By exposure to a process of evaporation, the body may then be reduced to twelve or fifteen. Perfectly dry mummies are sometimes found to weigh only seven or eight. Hence the fluids may be said to constitute by far the largest proportion of the body.

23. The fluids vary exceedingly at different periods of life. In youth, they are very abundant, making the form plump and round. In old age, they are greatly diminished, leaving the form shrunken and wrinkled.

24. The fluids contain in solution the materials for the formation of the solid tissues, and are also the medium through which all the waste particles are carried out of the system. The fluids and solids, being alternately converted into each other, do not differ essentially in their chemical elements.

25. The human body has been found, by chemical analysis, to contain the following elementary substances: Oxygen, hydrogen, nitrogen, carbon, sulphur, phosphorus, silicon, chlorine, fluorine, iron, and sometimes manganesium, aluminum, and copper.

26. The first four are most constant and most abundant, and are named essential elements.

27. The solid portions of the body are called *tissues*.

How are the substances which compose animal bodies divided? How many pounds of fluid may be drawn from the body of a man weighing one hundred and fifty pounds? How can the weight of the body be farther reduced? When are the fluids most abundant and when least abundant? How many elementary substances are there in the human body? Which are the four essential elements? What are the solid portions of the body called?

28. The *tissues*, in their primary formations, are made up of granules, nuclei, cells, filaments, and fibres.

29. Granules are particles of various sizes, from immeasurable minuteness to the ten-thousandth of an inch in diameter. Granules are found floating in milk, chyle, and other animal fluids, and imbedded in most of the tissues.

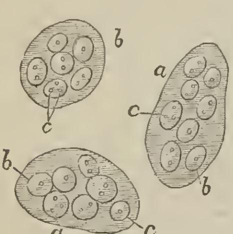


Fig. 1.—PARENT CELLS.—
a, *a*, Parent cells.
b, *b*, Secondary cells.
c, *c*, Nuclei.

30. *Nuclei* are the germ and centre around which cells are formed. (*Fig.* 1.)

31. *Cells* are minute bubbles, vesicles or scales. Their natural shape is oval or spheroidal, but they often become flattened or many-sided by pressure, as may be illustrated by filling a vial with a strong solution of soap in water, and then inverting it, when it will be filled with bubbles, each one of which will assume a form in accordance with the position it occupies. The cells perform a highly important process in all animal and vegetable structures. The solid portions of plants, and the tissues of animal bodies, are formed directly by the deposition of cells, or by the indirect elaboration of their fluid contents. They are concerned, not only in the functions of nutrition, in the development and restoration of parts, but in absorption and secretion. They are developed into tissues in various ways. In some, the cell-membranes become elongated, and are folded and divided into threads or filaments of exceeding fineness.

32. *Tubules*, or little tubes, are several cells elongated, and placed end to end—the partitions being removed.

33. *Filaments*, or fibrils, are exceedingly delicate threads, composed of minute particles, usually arranged in parallel bundles or fasciculi. (*Fig.* 2.)

Of what are the tissues made up? What are granules? Where are granules found? What are cells? How are cells developed into tissues? What are tubules? What are filaments?

Fig. 2.—Fasciculi and fibres of cellular tissue. *A*, White fibrous element, with cell-nuclei visible in it. *B*, Yellow fibrous element, showing its branching fibrils. *C*, Finer fibrils of the yellow element.

34. *Fibres* are larger than fibrils, but are similar in other respects.

35. A *tissue* is the union or interlacement of one or more of these primary structures.

36. An *organ* is an instrument composed of tissues, and designed for action. Its action is called its function or use. Thus, the liver is an organ, and the secretion of bile its function.

37. An *apparatus* consists of a number of different organs, arranged for the performance of some one office. The teeth, mouth, stomach, intestines, &c., belong to the digestive apparatus.

38. A *system* is a connected series of similar parts, such as the muscular or the nervous system.

39. The number of tissues which make up the different organs of animals is variously stated, according to the minuteness of description which different anatomists adopt.

What are fibres? What is a tissue?—an organ? What is an apparatus? —a system?

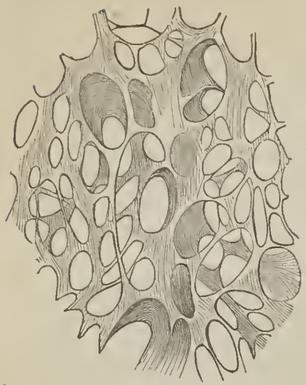


Fig. 3.—A magnified representation of a portion of areolar tissue.

40. The *cellular* or *areolar* tissue (*fig.* 3) is regarded as the primary form of all the others. It is formed by the crossing or interlacing of minute fibres, interwoven in every direction, so as to form a web-like membrane with innumerable small spaces, which communicate with each other, as is shown by filling them with air or water. When the lung and cellular tissue are pierced, as sometimes happens in fractures of the ribs, the external air passes from the lung into this tissue, and continues inflating it till the whole body becomes enormously distended with air, causing suffocation and death. In the progress of disease, the watery portions of the blood are sometimes effused into this membrane, causing dropsy. When the finger is pressed on a dropsical limb, a hollow or depression is produced by the forcing out of the fluid from this tissue at that particular point.

41. The *cellular* tissue is found in every part of the system, except in compact portions of bone, teeth, and cartilage. Its chief use seems to be to connect together organs and parts of organs which require a certain degree of motion on each other. It possesses great power of extensibility and elasticity.

42. Various names have been assigned to the cellular membrane, corresponding to the different positions in which it is found. When inclosing those organs not exposed to

What tissue is the primary form of all others? How is the cellular tissue formed? How is the cellular tissue sometimes inflated? Where is the cellular tissue found? What is its chief use? What different names have been given to the cellular tissue?

the air, it receives the name of *serous* membrane, from a fluid secreted in it, called serum. In the lining of the respiratory passages and of the alimentary canal, it is called *mucous* membrane, from a secretion of mucous which is poured out from numerous glands beneath its surface. Where it forms a covering for the body, it is known as the *dermoid* membrane, or skin.

PLATE III.

ORGANS OF CIRCULATION.

FIGURE 1.——*Front View of the Heart.*—*a*, Right auricle. *b*, Right ventricle. *c*, Left auricle. *d*, Left ventricle. *e*, Aorta. *f*, Pulmonary artery. *g*, Superior vena cava. *h*, *h*, Coronary veins and arteries—the nutrient vessels of the heart.

FIGURE 2.——*Section of the Heart, showing its Cavities and Partitions or Septa.*—*a*, Right auricle. *b*, Right ventricle. *c*, Left auricle. *d*, Left ventricle. *e*, Aorta. *f*, Pulmonary veins. *g*, Superior vena cava. *j*, Right pulmonary veins. *k*, Left pulmonary veins.

FIGURE 3.——*Ideal View of the Circulation.*—*a*, Right auricle. *b*, The entrance of the superior vena cava. *c*, The inferior vena cava. *d*, Tricuspid valves. *e*, Right ventricle. *f*, Pulmonary artery. *g*, *g*, Branches of pulmonary artery. *h*, *h*, Capillary vessels of the lungs. *i*, Pulmonary veins. *j*, Left auricle. *k*, Bicuspid valve. *l*, Left ventricle. *m*, Arch of the aorta. *n*, *n*, Arteries which distribute the blood to the head and upper extremities. *o*, Descending aorta. *p*, *p*, Capillary vessels of the systemic circulation.

FIGURE 4.——*Capillaries.*—This figure represents a highly magnified view of the arrangement of the capillaries, between the branches of the arteries and veins, as found in an intestinal villus. *a*, Arteries. *b*, Veins.

Fig. 1.

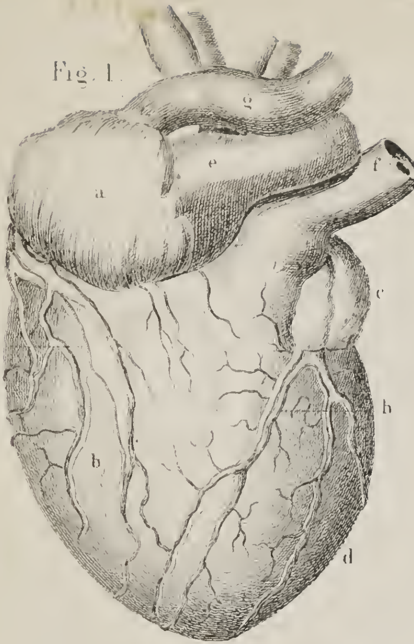


Fig. 4

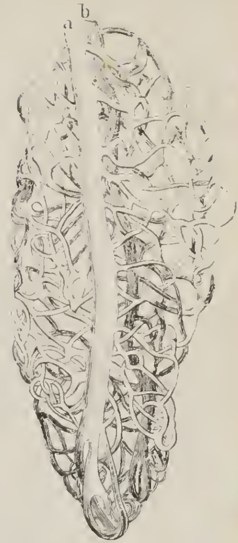


Fig. 2.

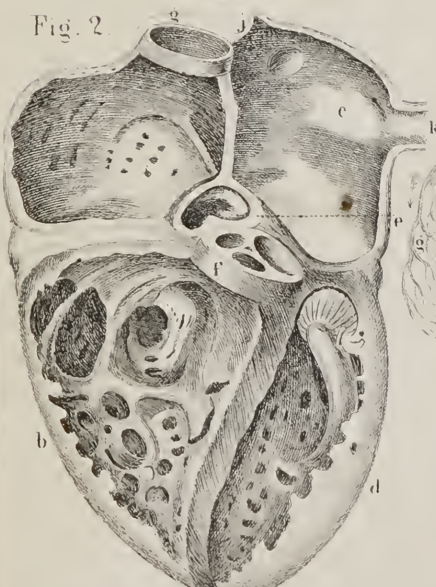
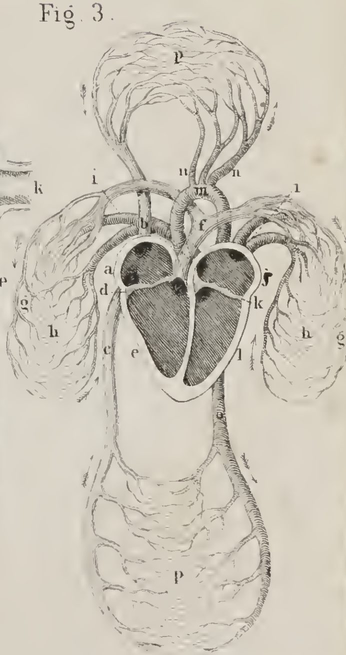


Fig. 3.



CHAPTER III.

THE BLOOD.

43. In all organized beings, the process of nutrition is carried on by means of a circulating fluid. In plants, this fluid is called *sap;* in animals, it is called *blood.*

44. The *blood* of insects is white or colorless. In fishes, it is red in the gills, heart, and liver; but nearly colorless in the main bulk of the body. In the mammalia, birds, and reptiles, it is of a dark purple color when drawn from a vein, and of a bright scarlet when it comes from an artery. It emits an odor peculiar to the animal from which it is taken.

45. In a few minutes after blood is taken from a living animal, it begins to coagulate, and become solid, like a soft jelly. If allowed to stand for a few hours, the clot will be found diminished in size, but firmer than before, and floating in the midst of a yellowish fluid, called *serum.*

46. The serum, or liquid, which remains after coagulation, is composed principally of albumen and water.

47. *Albumen* forms a very large proportion of the brain, the spinal cord, and nerves. It is perfectly colorless when pure, and is coagulated or hardened by either heat or acid. An example of it may be found in the white of an egg.

48. The *water* of the blood is always one of its most important constituents, and always forms by far the greater proportion of its bulk—one thousand parts of the blood containing from seven to eight hundred parts of water. The amount given off in perspiration, the state of the atmosphere, the fluid drank, and many other circumstances,

How is the process of nutrition carried on in organized beings? What is this fluid called in plants?—in animals? What is the color of the blood in insects?—in the mammalia, birds and reptiles? How does the blood coagulate? Of what is the serum composed? Of what tissues does albumen form a large proportion? What are some of the characteristics of albumen? What proportion of the blood is water? What circumstances influence the quantity of the blood?

increase or diminish this portion of the blood, and make it subject to frequent variations in quantity.

49. The clot or *crassamentum* is composed of fibrin and numerous red particles, called blood discs or corpuscles.

50. *Fibrin* is white when obtained pure, as it may be by repeated washings. Its peculiar property is to coagulate spontaneously. It forms the basis of the muscles, and is found in lymph and chyle. It is also found in solution in the serum, as the blood flows in the vessels of a living part, but coagulates soon after the blood is exposed to the air, and forms first a jelly-like mass, and then, as the contraction progresses, it entangles the coloring matter, and presses out the serum—thus forming an imperfect analysis of the blood.

51. The *blood discs*, which contain the coloring matter, have a size and form peculiar to each species of animal in which they exist. In man, they are little round cells, flattened like a piece of money, and from $\frac{1}{4000}$ths to $\frac{1}{2800}$ths

Fig 4.—*A*, Corpuscles of human blood, magnified five hundred diameters. *a*, Particles collected in a columnar form. *B*, Red particles of the blood of the common fowl. *b*, A particle seen edgeways.

of an inch in diameter. (*Fig.* 4.) In birds, reptiles, and fishes, they become necessarily larger, till, in some species of fish, they present a surface about six times as large as those found in man. The number of the blood discs correspond very much to the temperature of the animal. In warm-blooded animals, they form from twelve to fifteen

Of what is the clot composed? What is the color of fibrin when pure? What is its peculiar property? In what is it found? How does the coagulation of the blood form an imperfect analysis of the blood? What is the color and form of the blood discs? What is the size of the blood discs in different animals?

per cent. of the whole mass of the blood; in birds, fifteen per cent.; in man, twelve or thirteen per cent. In some of the cold-blooded animals—in fishes, for example—they form only five or six per cent. of the whole weight of the blood. The coloring matter of the blood discs contains nearly seven per cent. of iron. In certain diseases, in which the proportion of iron is diminished below the natural standard, the capacity of maintaining animal heat has been found correspondingly reduced. In such cases, some preparation of iron has been found the best remedy. From these facts it is inferred that the blood discs perform an important office in maintaining animal heat.

52. By chemical analysis, the blood is found to have nearly the same elements, combined in the same proportions as they exist in the flesh of the animal. It is therefore better fitted to renovate the tissues, and to carry nutriment to every part of the system—to furnish at one point the elements of bone; at another, those of muscle; at another, those of brain, and so on. The blood also takes up and carries off, through appropriate organs, all waste particles; thus maintaining in the body a continuous round of organization and decomposition—of growth and decay—a perpetual change of particles, new and old.

CIRCULATION OF THE BLOOD.

53. The organs by means of which the blood is carried from one part of the body to the other, constitute the circulatory apparatus, and the course of the blood through the organs is called its circulation.

54. If we commence with those animals which are low-

What the number? Under what circumstances is the iron found to be diminished? What is the remedy in such cases? In what vital process do the blood discs perform an important office? What elements is the blood found to possess by chemical analysis? What does the blood carry to every part of the system? What does the blood take up and carry off? What is the circulating apparatus? What the circulation? What is the condition of the circulatory apparatus in different orders of animals?

est in the scale of organization, we shall find the apparatus for circulating the blood exceedingly simple, though it becomes more and more complicated as we ascend to higher orders.

55. In insects, the blood is sent to various parts of the body by the alternate contractions of different portions of a central vessel which runs along the back, and thus forms a rudimentary heart. (*Fig.* 5, and *fig.* 1, Pl. I.)

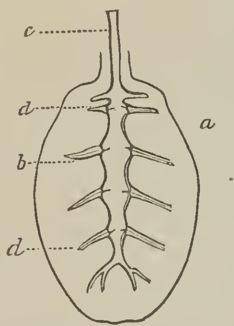


Fig. 5.—Dorsal Vessel of the Spider.—*a*, the abdomen; *b*, the dorsal vessel or heart; *c*, a trunk passing to the head; *d*, *d*, vessels communicating with the organs of respiration.

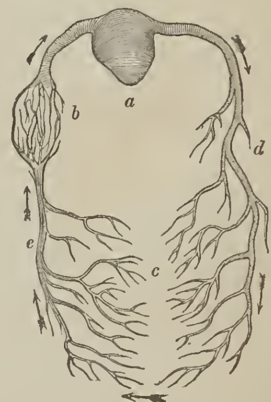


Fig. 6.—Circulation in Crustacea.—*a*, heart; *b*, gills; *c*, circulation through the body; *d*, arteries; *e*, veins.

56. Among the crustacea—of which the crab, lobster, craw-fish, &c., are examples—there is a single sac or ventricle, which receives the blood from the gills, and propels it to other parts of the body. (*Fig.* 6, and *fig.* 2, Pl. I.)

57. In fishes, we have a distinct heart with two cavities—an auricle or reservoir, and a ventricle or propelling organ. (*Fig.* 7, and *fig.* 4, Pl. I.)

58. Reptiles and the perfect amphibia, such as the frog

How is the blood sent to the various parts of the body in insects? How in the crustacea? What is the circulating apparatus in fishes?—what in reptiles?

and the snake, have two auricles and one ventricle. (*Fig.* 8, and *figs.* 5 and 6, Pl. I.)

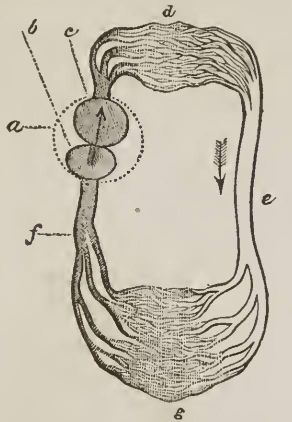


Fig. 7.—Circulation in Fishes.—*a*, heart; *b*, auricle; *c*, ventricle; *d*, circulation through the gills, or lesser circulation; *g*, circulation through the body, or greater circulation; *e*, arteries; *f*, veins.

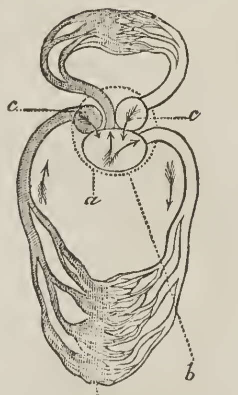


Fig. 8.—Circulation in Reptiles.—*a*, heart; *b*. ventricle; *c*, *c*, auricles.

59. In the mammalia (those animals which nurse their young) and in birds, we find parts equivalent to two hearts, such as exist in fishes, with a complete double circulation. (*Fig.* 9.) The heart is constructed on the same general plan in the entire group of warm-blooded animals, so that the heart of an ox, a sheep, or a dog, may be taken to illustrate the human heart.

60. The form of the double heart is somewhat like a pear, as represented in *fig.* 1, Pl. II. and *fig.* 1, Pl. III. In man, it is situated in the front part of the thorax, between the lungs, with its base or broader part inclining obliquely backward and upward towards the right shoulder, and its apex pointing forward and to the left side, between the fifth and sixth ribs, where its beatings are most distinctly felt.

Describe the heart, as found in mammalia and in birds? What is the form of the double heart? Where is the heart situated in man?

61. The *heart* is protected from friction against other organs by a smooth serous membrane, called *pericardium* by anatomists, and the heart-case by butchers. The pericardium is not only spread over the external surface of the heart, but is reflected or doubled on itself in such a manner as to form a closed sac or bag, as represented in *fig*. 10.

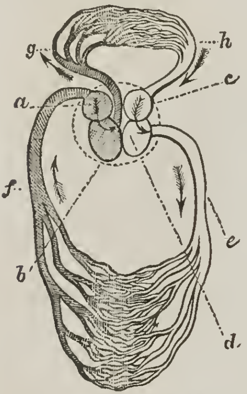


Fig. 9.—CIRCULATION IN MAN.—*a*, right auricle; *b*, right ventricle; *c*, left auricle; *d*, left ventricle; *e*, aorta; *f*, vena cava; *g*, pulmonary artery; *h*, pulmonary veins.

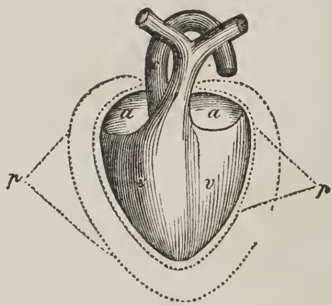


Fig. 10.—DIAGRAM OF THE PERICARDIUM.—*a*, *a*, auricles; *v*, *v*, ventricles; *p*, *p*, pericardium.

62. The heart itself is divided in the direction of its length, into two halves, each representing a single heart. The walls of the left half are thicker and stronger than those of the right. The reason is obvious: the right sends its contents only to the lungs, in its immediate proximity, while the left propels the blood to all parts of the system. The walls of the auricles are also much thinner than those of the ventricles, which require greater strength to act as propelling organs. The office of the auricles is

How is the heart protected from friction against other organs? Describe the pericardium. How is the heart divided? Which half has the thickest and strongest walls? Why are the walls of the left half thicker and stronger than the right? How do the walls of the auricle compare with those of the ventricle? What is the office of the auricle?

only to receive the blood as it flows from the veins, and their walls are accordingly thin and flabby.*

63. The auricles and ventricles are separated from each other by triangular folds of membrane (*fig.* 11) on the right side, called *tricuspid* valves (three-pointed), and on the left *bicuspid* (two-pointed) valves. These valves are attached to the walls of the ventricle by little muscular cords, which prevent them from being forced up into the auricle during the contractions of the ventricle. (*Figs.* 3 and 4, PL. IV.) This simple mechanism is so perfect as wholly to prevent the flowing back of the blood into the auricle.

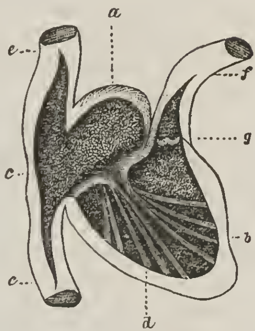


Fig. 11.—SECTION OF RIGHT SIDE OF THE HEART.—*a*, right auricle; *b*, ventricle; *c*, orifice between the tricuspid valves, *d*; *e*, *e*, ascending and descending venæ cavæ; *f*, pulmonary artery.

64. There are also three valves at the entrance of the aorta or large artery, and the same number at the orifice of the pulmonary artery. These six valves are named semi-lunar, from the half-moon shape of the folds of mem-

How are the auricles and ventricles separated from each other? How are the valves attached to the walls of the ventricle? Describe the semi-lunar valves.

* The comparative thickness of the walls of the ventricle, and the structure of the valves, may be illustrated most easily by examining the heart of some animal. For this purpose, the main vessels should be cut off high up, and all the fatty portions carefully removed with a knife. The pericardium should be opened one-half the distance round the heart, and then turned off to expose the heart, or to be rēplaced at pleasure. The comparative thickness of the walls of the ventricles is seen by making a transverse section through the heart, about one-third the distance from the apex to the base. By a perpendicular incision through each of the external walls to the margin of the auricle, the cuspid valves, with their delicate tendons, are fully exposed. The auricles may be cut away at their margins. The semi-lunar valves may be exposed, by cutting away successive portions of the aorta and pulmonary artery.

brane. They are attached to the walls of the artery at its exit from the ventricle, and each fold forms one-third of a circle. (*Figs.* 4 and 6, Pl. IV.)

65. When either set of valves becomes diseased, or fail to perform their office perfectly, the heart becomes irregular and labored in its action, and in some instances sudden death ensues.

66. The arteries, veins, and capillaries are the channels of communication between the heart and the various parts of the body.

67. The arteries are cylindrical tubes, composed of three principal coats—external, middle, and internal.

68. The *external*, or resisting coat, forms a strong tough investment to the artery, and gives it its power of resistance to the heart's actions.

69. The middle, or *fibrous* coat, is composed of elastic tissue, disposed in an oblique direction around the artery, and has for its office to equalize the flow of blood through the vessels. If the heart impelled the blood through an inelastic tube, at each impulse of the heart a quantity of blood would be ejected with a jerk from the other end of the tube, and it would cease to flow in the intervals of the heart's contractions. The elasticity of this coat enables the vessel to accommodate itself to the quantity of blood which may be thrown into it, and its alternate distention and contraction serves to continue the propulsion of the ventricle to the remotest extremities of the arteries with a constant flow of blood.

70. The contractile power of the middle coat enables the arteries to close their divided extremities when they have been cut or torn, so as sometimes to prevent hemorrhage. If the artery be large, a ligature is usually found necessary;

What consequences follow disease of the valves? What vessels are the channels of communication between the heart and the various parts of the body? Describe the arteries? What is the use of the external coat of the artery? Of what is the middle or fibrous coat composed? What advantages are derived from the elasticity of the middle coat? How is hemorrhage sometimes arrested in the smaller arteries?

but the smaller branches seldom require it. This contraction of the divided end may be increased by the application of cold or of stimulating substances, or by simply pricking or twisting the cut end of the artery. Fatal hemorrhage is thus often prevented by irritating applications, or by the violence with which the vessels are torn asunder.

71. The internal coat is a thin serous membrane, which lines the interior of the artery, and gives it a smooth, polished surface, along which the blood may flow with the least possible amount of resistance from friction.

72. The *arteries* gradually diminish in size towards their extremities, and finally terminate in minute hair-like vessels, which are too small to be seen with the naked eye. As they approach their extremities, the divisions and ramifications of the arteries are exceedingly numerous, forming frequent communications or *anastomoses* with each other; so that in case of obstructions in one of the main trunks, numerous lateral branches keep up a supply of arterial blood to parts that would otherwise perish for want of it. These anastomoses are very numerous in the arteries of the limbs and about the joints.

73. The *veins* are composed of three coats, like the arteries, but are much thinner in structure, and do not retain a cylindrical form when emptied of their contents, but become flattened or collapsed. The veins commence by minute vessels in the capillaries, and unite to form larger and larger branches, till they terminate in large trunks which return the blood to the heart. The velocity of the blood in the veins is less than in the arteries, and their

What is usually necessary to arrest hemorrhage from the large arteries? How may the contractions of the divided end of an artery be increased? Describe the internal coat. How do the extremities of the arteries finally terminate? How is the danger of obstruction in the large trunks obviated? Of how many coats are the veins composed? What is their structure? How do the veins commence? How does the velocity of the blood in the veins compare with that of the arteries?

diameter correspondingly greater. When the veins are liable to pressure from the muscles between which they run, they are abundantly furnished with valves, similar in form to the semi-lunar valves of the aorta and pulmonary artery. The free margins of the valves are turned towards the heart, so as to prevent any backward movement of the blood. By pressing a finger on one of the veins of the back of the hand, near the wrist, and drawing it towards the knuckle, one or more of these valves can be easily found. (*Fig.* 12.)

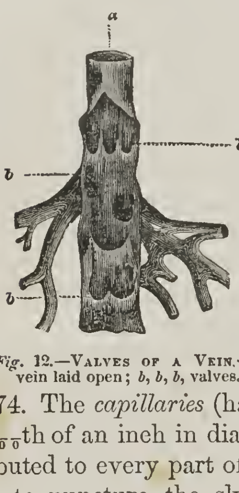


Fig. 12.—VALVES OF A VEIN.—*a* vein laid open; *b*, *b*, *b*, valves.

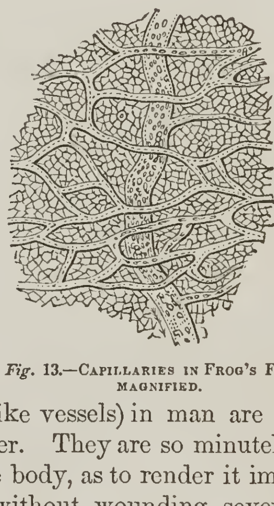


Fig. 13.—CAPILLARIES IN FROG'S FOOT MAGNIFIED.

74. The *capillaries* (hair-like vessels) in man are about $\frac{1}{3000}$th of an inch in diameter. They are so minutely distributed to every part of the body, as to render it impossible to puncture the skin without wounding several of these microscopic vessels. In the capillaries, the blood is brought in immediate contact with the tissues, and parts with its nutritive elements. They are the medium through which the functions of nutrition and secretion are performed, and the channels of communication between the arteries and veins. *Fig.* 13 shows a magnified representation of these vessels in the foot of a frog. *Fig.* 4, PL. III., displays their arrangement in the human intestine.

What is said of the valves in the veins? Describe the capillaries? What functions are performed through the capillaries?

PLATE IV.

ORGANS OF CIRCULATION.—HEART AND LUNGS.

Figure 1.——*Front View of Heart and Lungs.*—Both organs are stripped of their envelopes, the pleura and pericardium. The right lung is drawn aside, so as to uncover the heart and large vessels. The left lung is deeply dissected, to show the distribution and mode of ramification of the air-tubes and blood-vessels.

a, The larynx. *b*, The trachea.—The right lung is somewhat shorter than the left, and is divided into three lobes, *c*, *d*, *e*, while the left lung has but two lobes, *f*, *g*. The surface of the lobes is sub-divided into lobules, by the intersection of great numbers of depressed lines. *h*, Right auricle of the heart. *i*, Right ventricle. *j*, Left auricle. *k*, Left ventricle. *l*, The aorta. *m*, The pulmonary artery. *n*, Left pulmonary veins.—These veins are four in number, two for each lung; and they return to the heart the blood which has been conveyed into the lungs by the pulmonary artery. The division of the pulmonary artery into right and left branches, cannot be seen in this figure, being hidden by the aorta. *o*, The superior vena cava. *p*, Root of the right innominate artery, springing from the arch of the aorta. *q*, Root of the left sub-clavian artery. *r*, Root of the left carotid artery.

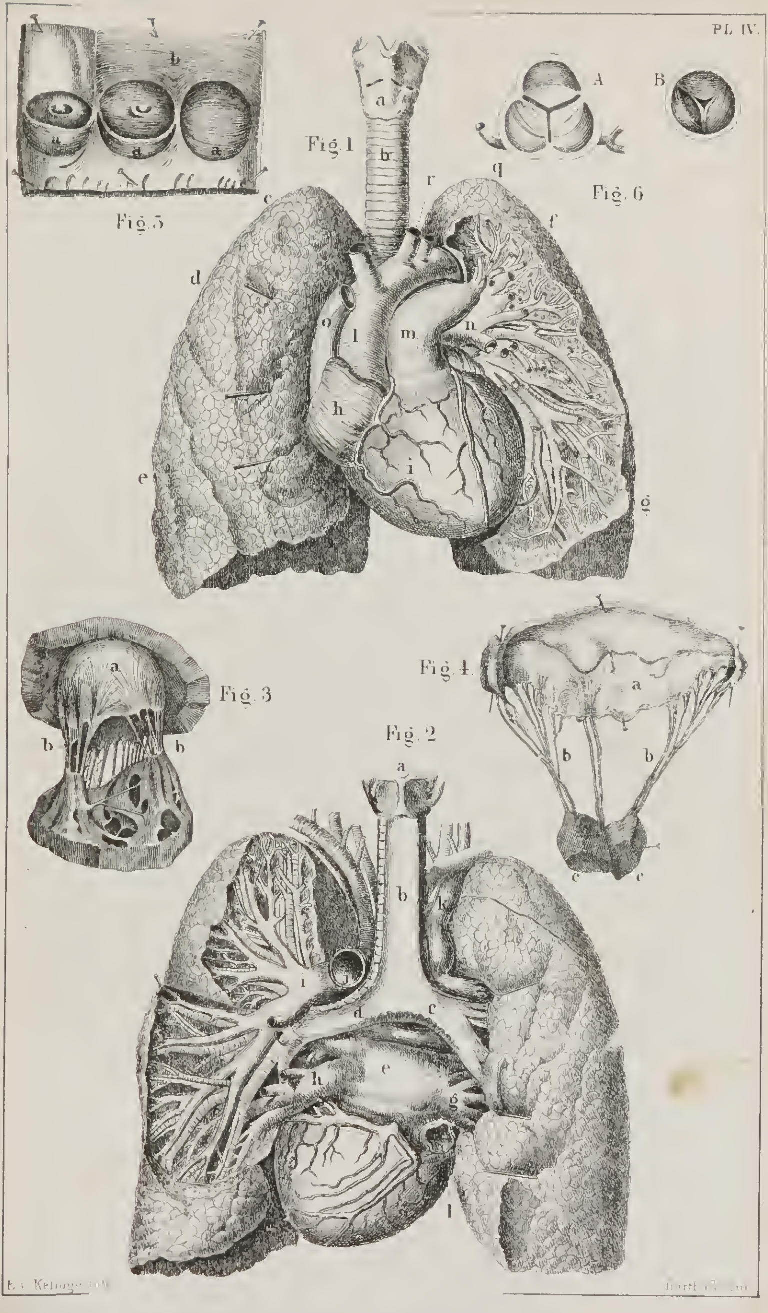
Figure 2.——*Back View of the Heart and Lungs.*—*a*, Larynx. *b*, Trachea. *c*, Right bronchus. *d*, Left bronchus. *e*, Left auricle of the heart. *f*, Left ventricle. *g*, Right pulmonary veins. *h*, Left pulmonary veins. *i*, Left pulmonary artery. *j*, Section of the aorta. *k*, Trunks of the brachio-cephalic veins (those which belong to the arms and head). *l*, The opening of the inferior vena cava.—The sub-divisions of the pulmonary arteries and veins, and of the air-tubes or bronchi, are seen accompanying each other in the left lung in both figures.

Figure 3.—*Bicuspid Valve.*—*a*, Membrane which forms the valve. *b*, *b*, Columnæ tendinæ, cords by which the folds are drawn together.

Figure 4.——*A portion of Tricuspid Valve.*—*a*, Membrane of one of the folds. *b*, *b*, Columnæ tendinæ. *c*, *c*, Portions of the walls of the ventricle.

Figure 5.——*Semi-lunar Valves, with Aorta laid open.*—*a*, *a*, *a*, Folds of membrane. *b*, A portion of the aorta.

Figure 6.——*Semi-lunar Valves.*—*A*, Folds of membrane. *B*, Valves of aorta.


PL. IV.
Fig. 1
Fig. 2
Fig. 3
Fig. 4
Fig. 5
Fig. 6
A
B

75. The course of the blood in the circulation of man may be easily understood, by reference to *fig.* 3, Pl. III. Commencing, we will suppose, with the left ventricle (*l*), the blood is impelled through the semi-lunar valves into the aorta (*m*), and along its successive branches to the microscopic net-work of the capillaries (*p p*), which ramify through all the tissues of the body. In the capillaries, the blood parts with its nutritive elements, becomes venous, and is collected into the small veins, and flows through their converging branches into the main trunks, the venæ cavæ (*b* and *c*), and finally into the right auricle (*a*). From the right auricle it is emptied through the tricuspid valves (*d*) into the right ventricle (*e*). This completes the great or systemic circulation.

76. From the right ventricle the blood is impelled through the semi-lunar valves into the pulmonary artery, and along its branches (*g g*) to the capillaries of the lungs, to be exposed to the action of the air. From the pulmonary capillaries the blood enters in converging streams the pulmonary veins (*i i*), which carry it to the left auricle (*j*), and this completes the lesser or pulmonary circulation. It is then emptied through the bicuspid valves (*k*) into the left ventricle, where it started on its course.

77. At each contraction, the heart of a man in middle age, whose blood averages about twenty-eight pounds, empties itself of two ounces of blood, with a propelling force of about four and one-quarter pounds. The heart of such a person contracts about seventy-five times in each minute; so that, in every three minutes, twenty-eight pounds and two ounces pass through the heart, or a quantity equal to the weight of the entire blood in the body.

Describe the course of the blood in the circulation of man. What changes take place in the capillaries? What is the course of the blood from the right ventricle? Of how much blood does the heart of a man in middle age empty itself at each contraction? What is the amount of the propelling force of the heart? How many times does the heart contract in a minute? How long a time will twenty-eight pounds of blood require to pass through the heart according to this estimate?

78. By the rapidity with which poisons are transmitted from one part of the system to another, it is estimated that in man the blood completes its entire circuit of the arteries, capillaries, and veins of the greater or systemic circulation, and then of the pulmonary circulation, to its original starting point, (the left ventricle,) in less than one minute.

79. The frequency of the heart's action varies at different periods of life, being most frequent in infancy, and diminishing to old age. During the first year, the average number of pulsations in a minute is from one hundred and thirty to one hundred and fifty. At the seventh year, the number is from ninety to eighty-five; in middle life, it is about seventy-five; in old age, it is as low as sixty, or even fifty. In the female, the heart beats more frequently than in the male. The action of the heart is also accelerated or retarded by various circumstances affecting the nervous system. It is quicker after than before eating, and slower during sleep than when awake; in the evening, than in the morning; and in the sitting, than in the standing position. Fear, anger, and the stronger passions, move the heart to violent action. Melancholy or sorrow retard it, both in force and in frequency. Hence a temper of uniform good-nature is always conducive to long life, while frequent indulgence in fits of passion induce premature disease, and sometimes sudden death.

How long a time will be necessary, if we form our opinion from the rapidity with which poisons are transmitted? What is the frequency of the heart's contractions during the first year?—the seventh?—in middle life?—in old age? What other circumstances affect the frequency of the heart's action? What temper of mind is conducive to long life?

PLATE V.

ORGANS OF RESPIRATION.

Figure 1.——*Front View of the Cavity of the Thorax.*—*a*, *b*, *c*, Lobes of the right lung. *d*, *e*, Lobes of the left lung. *f*, *f*, The diaphragm, clothed with the pleuræ. *g*, *g*, Section of the ribs. *h*, Appendage to the breast-bone, called the ensiform cartilage. *i*, The heart covered by the pericardium, the left lung being drawn asido to display it. *k*, *k*, Internal jugular veins. *l*, *l*, Carotid arteries. *m*, Larynx.

Figure 2.——*Posterior View of the Cavity of the Thorax.*—*a*, The larynx. *b*, The trachea. *c*, *c*, The right and left bronchi. *d*, aorta. *e*, The heart. *f*, *f*, The diaphragm.

Figure 3.——*Lungs of a Frog.*—*a*, Hyoidean apparatus. *b*, Cartilaginous veins at the root of the lungs. *c*, *c*, Pulmonary sacs.

Figure 4.——*Section of the Lung of the Turtle.*

Fig. 1.

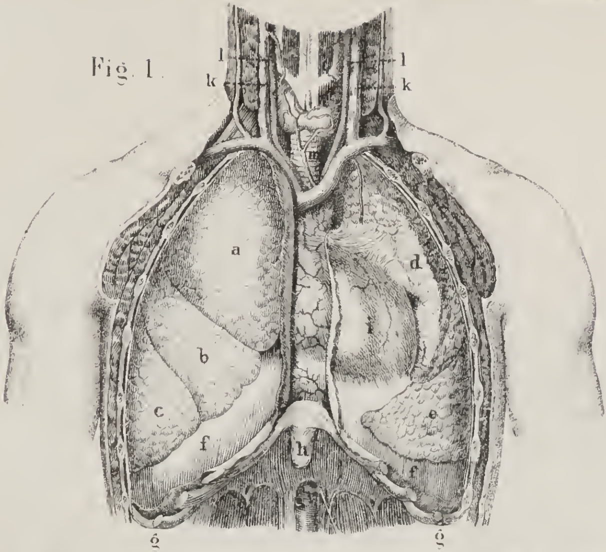
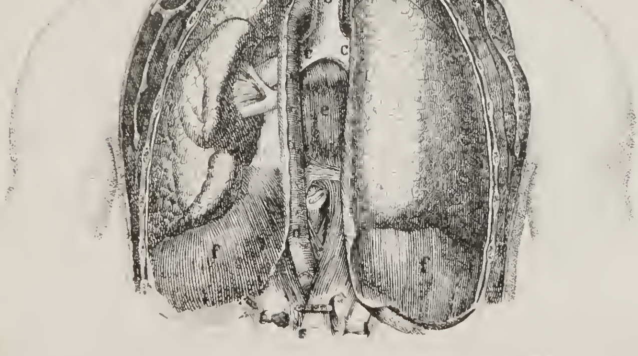


Fig. 3.

Fig 4.

Fig. 2.



CHAPTER IV.

RESPIRATION.

80. Respiration is that process by which a mutual interchange of elements is effected in every living being between its circulating fluid and the air. Plants cannot be perfected unless the ascending sap is exposed to its chemical action, and animals cannot maintain life without a perpetual renovation of the blood by its purifying influence. There is in every class some provision for exposing the nutritive fluids to the action of this essential element of vitality.

81. In plants, the process of respiration takes place in the leaves. Carbonic acid (which is composed of carbon and oxygen) is absorbed from the air, and decomposed:—the oxygen is set free or escapes from the leaves, and the carbon is absorbed by the sap, and transformed into the various tissues of the plant.

82. In animals, the process is reversed. Oxygen is absorbed, and carbonic acid, which is pernicious to animal life, is given off. Thus the two great kingdoms of nature mutually furnish those elements which are essential to the life of each other. Plants purify the air for the use of animals, and maintain in it a supply of that element, without which animals cannot exist. Animals, in turn, furnish the essential element for the growth of all vegetable structures, by parting with that which is useless and even poisonous to themselves.

83. In animals, the necessary condition for the function of respiration is a membrane supplied with the circulating

What is respiration? What is said of the necessity of respiration in plants and in animals? How does the process of respiration take place in plants? Of what is carbonic acid composed? How do plants dispose of the oxygen?—how the carbonic acid? How do animals dispose of the oxygen?—how the carbon? How do plants affect the air? What is the necessary condition for the function of respiration in animals?

fluid on one side, and the air on the other. But the same principle is so modified in the different groups of animals as to adapt it to their various modes of life. In some, this is the only condition; in others, there is a complication of organs, all tending to make this condition more perfect.

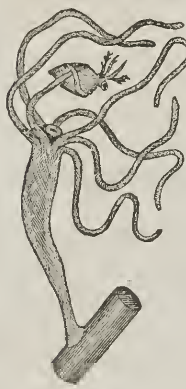


Fig. 14.—The Hydra, or Fresh-water Polype.

84. Thus, in the lowest groups, of which the hydra is an example (*fig.* 14), the respiration takes place through the whole surface of the animal, and is called cutaneous respiration. This kind of respiration is found to some extent in all the higher orders of animated beings, and is of no inconsiderable importance even to man. In many of the cold-blooded animals it is equally important with that performed by the special organs of respiration. The frog, for example, will live longer with his mouth and nostrils completely closed, than when his skin is coated with a substance through which the air cannot penetrate.

85. All the animals which possess a special organ of respiration may be divided in two large groups, viz: *water-breathing* and *air-breathing* animals. Each of these groups also presents two distinctive modifications of the respiratory organs, quite unlike each other.

86. In the lowest group of water-breathing animals, the respiratory organs consist of prolongations of the cutaneous covering into fringes, such as are represented in the

How is this principle modified in different groups of animals? How does respiration take place in the hydra? What is this kind of respiration called? In what other orders of animals is this kind of respiration found? What is said of its importance in cold-blooded animals?—in the frog? In how many large groups may all the animals which possess a special organ of respiration be divided? What modification in each of these? Describe the respiratory organs in the lowest group of water-breathing animals.

serpula. (*Fig.* 15.) In different orders of this group of animals, the fringes are found in very different forms. In some, they are attached to the head, and in others, to the side, and serve the double purpose of respiratory and locomotive organs.

87. In fishes, which belong to the highest group of water-breathing animals, the respiratory organs consist of a series of arches attached to the head, each of which is supplied with a vast number of thin elongated plates, collectively forming *gills*.

Fig. 15.—THE SERPULA.

88. The gills of fishes are made up of numerous little fibres, set close to each other, like the barbs of a feather. Each fibre contains a slender plate of cartilage, which gives it mechanical support, and enables it to preserve its shape while moved by the streams of water which are perpetually rushing through the gills. On the surface of the fibres are distributed myriads of blood-vessels, spread over every part like a delicate net-work. The whole extent of this surface, exposed to the action of air absorbed from the water, is exceedingly great. In the skate it is at least equal to the whole surface of the human body. The water itself does not act on the respiratory membrane, but is merely the vehicle by which the air is brought in contact with it. It is well known that fishes cannot live any length of time in a limited quantity of water which has no access to fresh air. When they are removed from the water, the filaments of the gills almost instantly flap together, and adhere in such

What is said of the form and attachment of the fringes? Describe the respiratory organs of fishes. The gills of fishes are made up of what? How do the fibres preserve their shape? What are distributed on the surface of the fibres? What is said of the extent of this surface exposed to the action of the air absorbed from the water? How great is it in the skate? Does the water itself act on the membrane? What does? How are fishes effected by being kept in water which has no access to fresh air?

a manner as prevents the exposure of a great portion of their surface to the air; but the portion which is exposed shortly becomes so dry, that the action of the air on the blood is soon suspended, and death ensues from imperfect oxygenation.

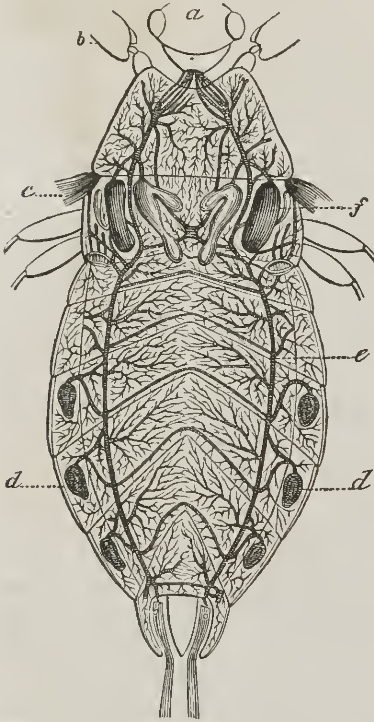


Fig. 16.—RESPIRATORY APPARATUS OF INSECT.—*a*, head; *b*, first pair of legs; *c*, origin of wing; *d*, *d*, stigmata; *e*, air-tubes or tracheæ; *f*, air-sacs.

89. In insects, which form the lowest group of air-breathing animals, there is a special provision for conveying air to the circulating fluids through tubes of thin delicate membrane. (*Fig.* 16.) The abdomen of an insect is made up of a series of joints, each of which is composed of two plates, one on the upper and one on the lower side. At the edges of each joint, where the two plates meet, there is an opening, called the *stigma*, through which the air passes into the tubes. These tubes extend to every part of the insect, and convey air to all the tissues, forming a very remarkable substitute for a circulation of the blood through a special organ of respiration.

90. The highest group of air-breathing animals possesses a distinct lung, which is found greatly modified in the

What takes place when they are removed from the water to the air? What is the cause of death? How is air conveyed to the circulating fluids of insects? Describe the air-tubes of insects. What do the highest group of air-breathing animals possess?

different classes of animals that belong to this group. The lung is seen in its simplest condition in the snail, (*fig.* 17,) where it consists of a respiratory sac with a blood-vessel distributed on its surface.

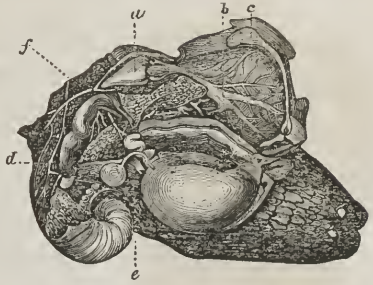


Fig. 17.—INTERIOR OF A SNAIL.—*a*, the heart; *b*, large blood-vessels branching over the sac, *c*; *d*, artery which conveys the blood to the general system; *e*, part of the stomach; *f*, the liver.

91. In frogs, the lungs consist of two bags, on the walls of which are cells of but very slight depth; the process of respiration is carried on through the membrane that forms the cells. (*Fig.* 3, PL. V.)

92. In turtles, the interior of the lungs is divided into several cavities which communicate with each other. (*Fig.* 4, PL. V.)*

In what animal is the lung seen in its simplest condition? Describe the respiratory organs of a frog—a turtle.

* A very beautiful preparation, to show the distribution of the blood-vessels over the membrane of the lung, together with the membrane itself, may be prepared from the lungs of a turtle. Procure a turtle at least six or eight inches in length, cut off the head, and immediately saw the lower shell from the upper at the sides, and then with a knife dissect off the muscles from the shell. When the shell is removed, almost the first object that arrests the attention is the heart, still performing its functions with as much apparent regularity as if nothing had happened, which it will continue to do for several hours, though its action grows more and more feeble. On either side of the heart, and partly under the scapulæ, the lung may be seen in a collapsed state. A quill should be inserted into the trachea, and the lungs inflated, for the purpose of rendering their position more apparent, when they can be easily removed with the scissors, though it must be remarked that the slightest scratch spoils the preparation. As soon as the lungs are removed, they should be inflated to their utmost capacity, a ligature applied to the trachea, and then hung in the air to dry. In half an hour you have an exceedingly handsome and useful preparation, which may be preserved for any length of time.

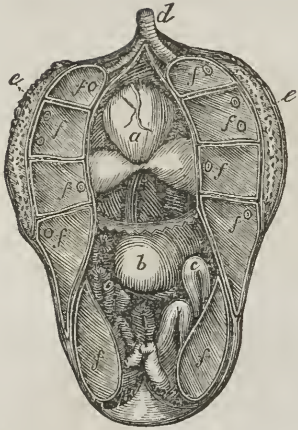


Fig. 18.—LUNGS OF THE OSTRICH.—*a*, the heart; *b*, the stomach; *c*, *c*, the intestines; *d*, the trachea or windpipe; *e*, *e*, the lungs; *f*, *f*, *f*, air-cells, in which are also seen the orifices of the tubes through which these air-cells communicate with the lungs.

93. In birds, the respiratory apparatus consists of two lungs, which are made up of numerous cells. The air also passes through the lungs into large sacs along the abdomen, and even into the bones. (*Fig.* 18.) Respiration in birds is more frequent than in any other class, and their movements are correspondingly more active. The large amount of air contained in the sacs and bones of birds must also serve to give them more lightness and buoyancy for their aerial flights.

94. The capacity of the lungs, as a respiratory organ, depends in each group of animals on the extent of the respiratory membrane, which is invariably increased in proportion as the cells become more numerous in a given space. Thus, in the entire group of warm-blooded animals, where the function of respiration is at its highest perfection, we find an almost infinite number of cells.

Fig. 19.—AIR-CELL, with blood-vessels branching over it.

95. In the human lungs it is estimated that there are at least six hundred millions of air cells, collectively presenting a surface equal in extent to about thirty times the whole surface of the body. Each cell, as is represented in *fig.* 19, is constructed on the same plan as the single air-sac of the snail, and consists of a thin delicate membrane, with an artery

Describe the respiratory organs of a bird. How do birds compare with other animals in the frequency of their respirations? What special benefit do birds derive from the large amount of air contained in their sacs and bones? Upon what does the capacity of the lung depend? In what group of animals are the air cells most numerous? How many air cells are there in the human lungs? How is each air cell constructed?

distributed on its surface in minute capillary vessels, which terminate in veins that carry the blood back to the heart.

96. The whole substance of the lungs is thus made up of these minute cells, with their air and blood vessels.

97. The lungs are supplied with air through the *larynx* and *trachea*. (*Fig.* 20.)

98. The *larynx* is an irregular cartilaginous tube, forming the upper extremity of the *windpipe*, as the whole tube is commonly called. The larynx is situated immediately below the root of the tongue, and forms the protuberance in the front part of the neck, called "*Adam's Apple.*" The larynx gives passage to the air which is inhaled into the lungs or exhaled from them, and contributes essentially to the production of vocal sounds.

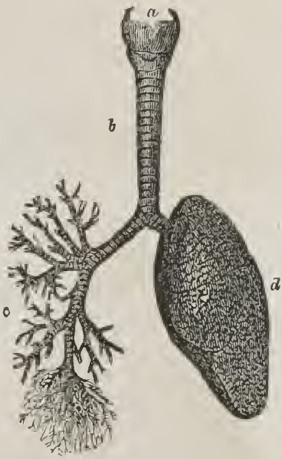


Fig. 20.—*a*, the larynx; *b*, the trachea; *c*, bronchial tubes; *d*, the left lung.

99. The trachea is composed of about eighteen cartilaginous rings, connected together so as to form a tube, which is capable of maintaining a uniform size.

100. On entering the chest, the trachea divides into two trunks, called *bronchi*, one of which goes to the right and the other to the left lung. As soon as the bronchi enter the lungs, they branch off into numerous divisions and sub-divisions, their ultimate extremities terminating in air cells. (*Fig.* 1, PL. VI.)

101. The human lungs occupy the greater part of the

Of what is the whole substance of the lungs mainly made up? How are the lungs supplied with air? Describe the larynx. How is the larynx situated, and what is it sometimes called? What other use has the larynx besides to give passage to the air? How is the trachea formed? How does the trachea divide on entering the chest? How do the bronchi divide? Where are the lungs placed in man?

chest, the heart being the only organ of much volume which is included in it. The size of the lungs in different individuals corresponds very nearly to the capacity of this cavity. Hence, persons with full broad chests rarely suffer from weak or consumptive lungs, while those who have narrow and contracted chests are as seldom exempt from these evils.

102. The chest, or *thorax*, is a cavity closed on all sides from the entrance of air, and its bony walls afford an admirable protection to the delicate organs included within it.

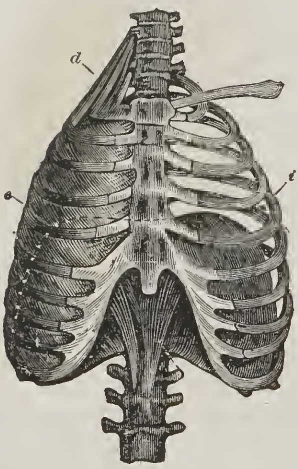


Fig. 21.—Human Thorax.

103. The walls of the thorax (*fig.* 21) are formed by the breast-bone in front, by the ribs and spine on the sides and back, and by the diaphragm below.

104. The ribs, to the number of twelve on each side, are attached to the bones of the spine by slightly movable joints, and to the breast-bone by flexible cartilages. The ribs are also connected to each other by the intercostal muscles.

105. The diaphragm (*fig.* 5, Pl. VI.) is a large muscular partition, which separates the chest from the abdomen.

106. The internal surface of the chest is lined throughout with a serous membrane, called the *pleura*, which is reflected over the external surface of the lungs. A serous fluid is constantly exhaled from this membrane, causing the parts to glide on each other free from friction.

How may we judge of the size of the lungs in different individuals? Describe the chest. How are the walls of the thorax formed? Describe the ribs—the diaphragm. How is the internal surface of the chest lined?—and how is it kept moist?

PLATE VI.

ORGANS OF RESPIRATION.

FIGURE 1.——*The Larynx, Trachea, and Bronchi.*—*a*, The larynx. *b*, The trachea. *c*, *c*, Bronchi. *d*, *d*, *d*, *e*, *e*, *e*, Outlines of the lungs. *f*, *f*, *f*, &c., Bronchial tubes.—These tubes continue to ramify, decreasing in size, until they can only be distinguished by the microscope. *g*, *g*, *g*, Lymphatic vessels and ganglia.

FIGURE 2.——*A Portion of the Tissue of the Lungs*, Showing the blood-vessels, capillaries, and air-tubes, magnified fifty diameters.—A vein, *a*, is represented ramifying with an artery, *b*, around the intricate air-cells, *c*, *c*.

FIGURE 3.——*The Plural Surface of a Portion of Lung*, magnified three diameters, showing the form and great abundance of the air-cells.

FIGURE 4.——*Plural Surface enlarged.*

FIGURE 5.——*The Diaphragm, separated from the Body.*—*a*, The right vault of the diaphragm, which is higher than the left. *b*, *b*, The right and left crura or pillars of the diaphragm, by which it is attached to the spinal column.

FIGURE 6.——*Lateral View of the Outlines of the Thorax and Abdomen.*—This figure is intended to show the respective positions of the diaphragm and the walls of the chest and abdomen, in inspiration. The dotted lines, *a*, *a* indicate the contour of the front of the chest and abdomen, when the chest is filled with air after inspiration. *b*, *b*, The line of the diaphragm, when it is contracted and flattened in inspiration, pressing down the abdominal contents, and causing the abdomen to project. *c*, *c*, The line of the chest and abdomen, after the air is expired. *d*, *d*, The arch of the diaphragm, when relaxed in expiration, rising into the interior of the thorax, and drawing inward and downward its point of attachment to the front of the body, *e*.

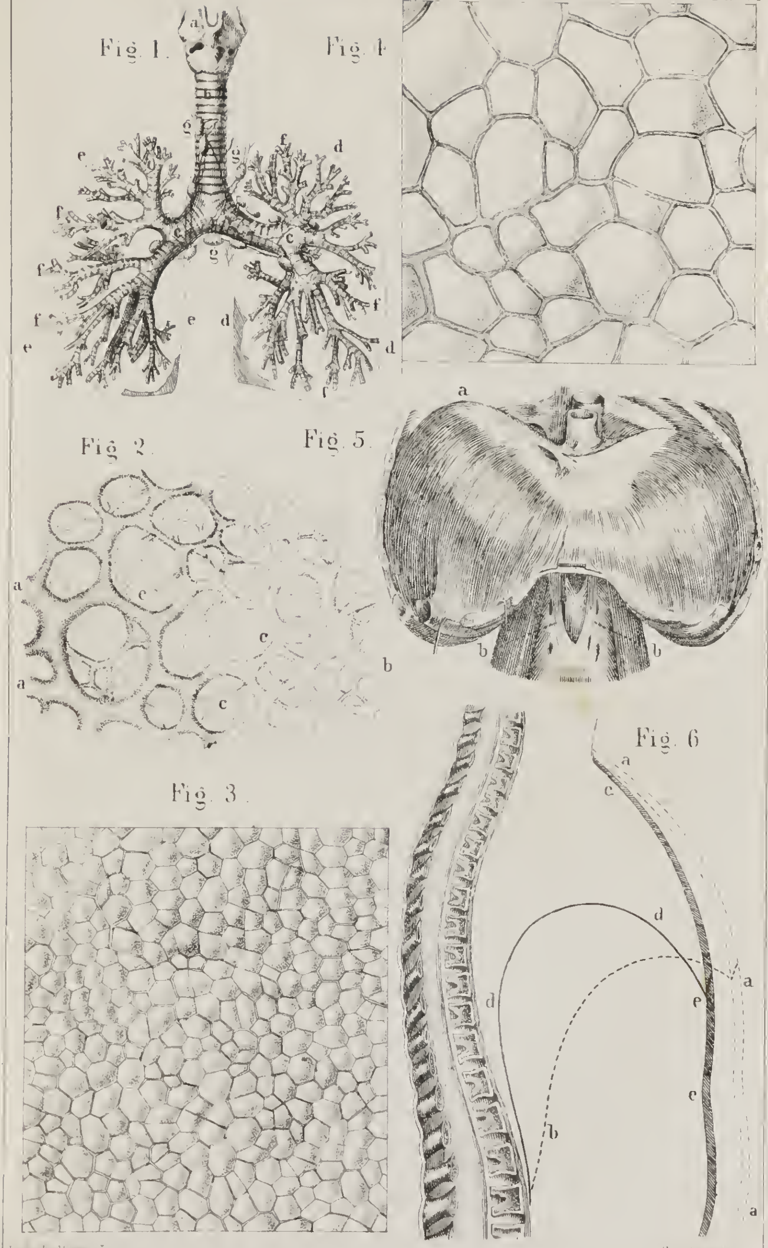

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Fig. 6

107. In the process of respiration, the cavity of the chest is constantly increased and diminished in size by the alternate elevation and depression of the ribs and diaphragm, as explained by *fig.* 6, Pl. VI.

108. When the lungs are empty, and the respiratory organs at rest, the ribs hang downward and inward, and the diaphragm extends upward into the cavity, reducing it to its smallest capacity. In the act of respiration, which inflates the lungs, the ribs are elevated, increasing the diameter of the cavity, and the diaphragm is at the same time depressed, increasing its length; thus making the capacity of the chest greater in all directions.

109. As the cavity of the chest is enlarged, air rushes into the lungs, and inflates them, to fill it just as perfectly as when at rest. The lungs are thus comparatively passive in the respiratory movements, always accommodating themselves to the size of the cavity in which they are contained. The active process of respiration is performed by the respiratory muscles (*d*, *e*, *i*, *fig.* 21,) attached to the ribs and by the diaphragm.

110. When the ribs are confined by a tight dress or otherwise, respiration is carried on mainly by the diaphragm. When the abdomen is so closely confined or so distended as to prevent the descent of the diaphragm, respiration is performed by the respiratory muscles attached to the ribs.

111. It is therefore a law of our organization that all parts of our dress should be loose about the chest and abdomen. When the fullest action of the respiratory organs is in any way restrained, respiration becomes correspond-

How is the cavity of the chest increased and diminished in size? What is the position of the ribs and diaphragm when the respiratory organs are at rest? What change takes place in the act of respiration? How is the chest filled when it is enlarged? By what organs is the active process of respiration performed? How is respiration carried on when the ribs are confined? How when the diaphragm? What law of our organization do these parts teach us?

ingly more frequent and more laborious. For this reason, all persons who diminish to any extent the capacity of the chest or of the abdomen, breathe oftener than is natural, and with slight exertions *pant* for breath, like one who has been taking most violent exercise.

112. Under ordinary circumstances, the number of inspirations of an adult are from fourteen to eighteen in each minute. In mental excitement or active exercise, they become more frequent. Infants and young persons breathe more rapidly than adults.

113. The average quantity of air taken into the lungs at each inspiration is about twenty cubic inches; at six teen inspirations in each minute, twenty thousand cubic inches of air pass through the lungs in an hour—making two hundred and sixty and one-third cubic feet in a day.

114. As the air passes through the lungs, it parts with about one-fourth of its oxygen, and receives nearly an equal amount of carbonic acid. It is also saturated with watery vapor, and warmed to nearly the same temperature as the blood.

115. In this process, the venous blood is purified of the waste and worn-out particles, which are taken up from the capillary circulation in the tissues, and converted into arterial blood.

116. It is estimated that in every minute a quantity of blood equal to the whole amount in the body is subjected to this renovating process in the lungs, and in every twenty-four hours about twenty ounces of watery vapor and six ounces of carbon are exhaled from the lungs.

When the action of the respiratory organs is in any way restrained, what is the effect on respiration? What is the number of respirations in adults? How is it affected by exercise or by excitement? How much air is taken into the lungs at each respiration? How much air will pass through the lungs in an hour? —in a day? How is the air changed in passing through the lungs? What change takes place in the blood during this process? How much blood is subjected to this renovating process every minute? What is exhaled from the blood?

117. If the lungs become diseased, so that their function is imperfectly performed, or if the air we breathe is already charged with impurities which have escaped from the lungs, or if there be an insufficient supply of air, the whole system suffers. The blood is burdened with an accumulation of impurities, and the nervous system becomes depressed and inactive for the want of pure arterial blood, its natural stimulus.

118. For this reason, persons who sleep in small imperfectly-ventilated rooms, feel languid and oppressed in the morning, instead of being refreshed and invigorated.

119. In churches and public assemblies, when there is an insufficient supply of pure air, a feeling of fatigue, languor, and head-ache is very soon experienced.

120. A due supply of pure air may be regarded as one of the most essential conditions of healthy respiration. Life cannot be sustained for any considerable time without air, nor can it be continued in carbonic acid gas. Therefore, every apartment we occupy, whether public or private, should be provided with reliable means for conveying off the poisonous gas and supplying the pure air.

121. When we consider the delicate structure of the lungs, and the absolute necessity of efficient ventilation, we are not surprised that one-fourth to one-third of our race are scourged with lung diseases; since little or no care has been taken to obey this imperious law of animal existence.

122. Every room not provided with that noble ventilator, *a fire-place*, should have an aperture for the entrance of pure air, and another for the exit of the gases thrown

If the lungs be diseased or the air be impure, what is the effect? What is the effect of sleeping in poorly-ventilated apartments? How are public assemblies affected by impure air? What is said of the importance of a due supply of pure air? With what should every apartment we occupy be provided? What proportion of our race are scourged with lung diseases? How should every room be ventilated?

off by respiration; and no family which neglects these conditions of health, can expect exemption from disease.*

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* A very interesting experiment, to illustrate the importance of ventilation, may be made by lowering a lighted taper or candle attached to a flexible wire into an open-mouthed glass jar, holding one or more pints. In a very few minutes carbonic acid will be found sufficient to extinguish the taper. That it is carbonic acid may be ascertained by pouring into the jar lime-water, which immediately becomes turbid from the formation of carbonate of lime. That carbonic acid is also produced by respiration may be made to appear by filling and inverting the jar in water; then pass the end of a tube (or, if nothing better be at hand, an open straw,) under the jar, and breathe through the tube into the jar till the water is entirely displaced. The hand, or a piece of glass or of brown paper, must now be put snugly on the mouth of the jar, which is to be inverted and placed on the table. On removing the hand, plunge the taper into the respired air, and it will be instantly extinguished. The necessity for a supply of oxygen may be shown by inverting the jar, and passing up the lighted taper. As fast as the oxygen is consumed, the nitrogen, which is lighter than atmospheric air, occupies the upper portion of the jar, causing the taper to grow dim or be extinguished, according to the position in which it is held.

CHAPTER V.

ANIMAL HEAT.

123. THE power of maintaining animal heat is closely allied with the process of respiration. In those animals which possess the most perfect development of the respiratory organs, the animal heat is maintained at a uniform temperature, whatever may be the variations of temperature in the surrounding medium.

124. In birds, respiration is more active than in any other class of animals, and their temperature is uniformly higher than any other, ranging from 106° to 112° Fahrenheit. In the mammalia, it is from 95° to 105°. In man, at adult age, it varies, in different individuals, from 98° to 100°. In fevers, it is several degrees higher: in scarlet and typhus fevers, as high as 106° or 107°. In health, it is about one degree and a half lower during sleep than when awake. Hence we always require additional clothing during sleep.

125. In the young of all animals, the temperature is a few degrees higher than in the adult, and respiration is correspondingly more frequent; but the sensibility to cold is much greater, and consequently the power of resisting it much less. For this reason, when young animals are exposed to a low temperature, without protection, the animal heat rapidly diminishes, and, if artificial heat be not afforded, death ensues.

126. Those animals which possess the power of maintaining a uniform standard of temperature, are called *warm-*

What relation has the power of maintaining animal heat to the process of respiration. How does the respiration and temperature of birds compare with other animals? What is the temperature in the mammalia?—in man? What is it in fevers? What during sleep? What is the temperature and respiration of young animals? How do they bear exposure to cold? What are those animals called which possess the power of maintaining a uniform temperature?

blooded animals. Reptiles, fishes, and all the lower order of animals, are cold-blooded.

127. In the snail, whose respiratory apparatus we have seen is exceedingly simple, the temperature is very little above that of the surrounding air. The temperature of fishes is always nearly the same as that of the water, rising or falling with the warmth or cold of the sea, river, or lake which they inhabit. In reptiles, which come nearest to warm-blooded animals in the development of the respiratory organs, there is the power to maintain the temperature of the body a few degrees higher than the surrounding medium, though this cannot endure a very low temperature without becoming torpid.

128. In some cold-blooded animals, a most remarkable provision exists for preserving life when the temperature of the body is reduced below the freezing point. As the cold increases, the organs become more and more inactive, until at length all the animal functions cease, and torpidity ensues. Some species of insects and fishes may be frozen solid like ice, and yet retain life, and again become active when exposed to a proper degree of warmth. The freezing appears to produce no chemical change, either in the tissues or the fluids; it merely suspends the operation of their affinities until, by a return of warmth, they are excited to action.*

What are those called which do not possess this power? What order of animals are cold-blooded? What is the temperature of the snail? What of fishes? What is the temperature of reptiles? What remarkable provision exists in some cold-blooded animals for preserving life at a low temperature? What examples are given? How is this fact explained?

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* Some very interesting phenomena have been observed in certain warm-blooded animals, which hybernate or spend the winter in a semi-torpid state. One of these hybernating animals, common in New England, is a species of marmot, usually called *woodchuck*. This animal enters his den or burrow about the first of October, closing the entrance after him with hard-packed earth. There he remains until about the first of April, most of the time enjoying a very profound sleep

129. A comparative view of the process of respiration, in connection with the development of animal heat, very clearly shows that the lungs, under the influence of the nervous system, are the organs which maintain the temperature of the body. The various tissues, together with the food, supply the blood with carbon, which combines with the oxygen of the respired air to form carbonic acid, and produce one hundred and thirty-five degrees of heat for every ounce of carbon. The chemical combination in this process is essentially the same as that of combustion.

130. The lungs, however, must not be regarded as the only source of animal heat. For it is probable that cer-

What does a comparative view of the process of respiration, in connection with the development of animal heat show? With what does the carbon of the blood combine? What is formed by this process? How does it compare with combustion? Are the lungs the only source of animal heat?

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and breathing just often enough to keep himself comfortably warm. During the five months which he remains in this condition, his whole number of respirations does not exceed those of eight or ten days of activity in the summer months. All hybernating animals become enormously fat in the autumn before they begin their "winter's-nap." This fat, which contains a very large proportion of carbon, is gradually absorbed, and combined with the oxygen of the lungs, in order to maintain the necessary temperature; and the animal comes forth from his hiding-place in the spring greatly emaciated, and with a most excellent appetite. During the long period of his sleep, digestion and the other animal functions not necessary to respiration have been entirely suspended, and the small supply of oxygen indispensable to his diminished respiration has been obtained from the air which penetrates through the earth to his burrow. These animals possess no peculiarity of structure by which they are particularly suited to this mode of life. They seem rather to have an instinctive impulse to adopt this economical method of passing the winter, because, during that season, their usual supply of food can no longer be obtained. Indeed, some other animals, whose habits do not commonly lead them to hybernate, have the power of prolonging life in a similar manner; and the same species which hybernate in a cold climate will not do so in a warmer one. This habit of sleeping through the winter seems, therefore, by a wise provision of the Creator, to be given to certain animals, in order to supply the failure of all other means of maintaining life.

tain chemical changes, resembling those in the lungs, are constantly taking place throughout the tissues of the body, whereby a small amount of heat may be evolved.

131. The variations of atmospheric temperature have long since been observed to exert an important influence over the health of the lungs. The diseases of the lungs prevail most during those months and in those localities where the weather is the most variable, and diminish most in proportion as the weather becomes more uniform.

132. To guard against lung diseases, constant care and vigilance must be exercised to preserve the warmth of the body as uniform as possible by artificial means. The clothing during winter should be sufficient uniformly to protect the body against sudden changes, and it should not be changed too suddenly or at too early a season for the thinner habiliments of hot weather: for it is much better to suffer a little inconvenience from the heat of flannels, in the spring, than to risk injury to the lungs by taking them off, as is too often done on the first warm day.

What other source is there? What causes affect the health of the lungs? When and where do diseases of the lungs prevail most? What is necessary to guard against lung diseases? What care should be exercised in regard to clothing?

CHAPTER VI.

DIGESTION.

133. DIGESTION is that process in animals by which the food is prepared for the nutrition and growth of the body.

134. The food of plants is derived from the earth and air around them, in a liquid or gaseous state, and is already adapted to their use. But the materials from which animals derive their nourishment require a certain degree of preparation before they can be taken up by the nutritive fluid.

135. All animals are therefore provided with organs by which their food is acted upon, so as to fit it to be conveyed into their systems; and in no organs of the body is the wisdom and skill of the Creator more manifest than in the means with which every animal is provided for securing a subsistence.

136. In those animals which live on food that requires but little preparation, the organs of digestion are very simple. In the class of *polypes*, for instance, a single sac or cavity, in which the food is dissolved, is all that is required.

137. In the higher orders, there is an apparatus for masticating or grinding the food; and instead of the single digestive sac of the polype, there are three distinct cavities: in the first, the food is mechanically divided; in the second, it is reduced to a pulpy mass; and in the third, its nutritive portions are taken up, to be conveyed into the circulating fluid.

MASTICATION.

138. The apparatus for *masticating* or dividing the food mechanically is found in accordance with the kind of food

What is digestion? From what source is the food of plants obtained? How do animals derive their nourishment? With what organs are all provided? In what animals are the digestive organs very simple? What do ve find in the higher orders? What is said in regard to the apparatus for masticating the food?

which the animal requires, and the rapidity with which the process of digestion is to be carried on.

139. If the process of digestion is to be performed rapidly, the food requires division into small portions, so as to present as large an amount of surface as possible to the solvent fluid. Thus, in those animals which chew or masticate their food most perfectly, the process of digestion is performed in a few hours; while in those which swallow their prey whole, as the snake, several days are required.

140. The apparatus for masticating the food presents a great variety of forms, and is modified in the different orders of animals according to the kind of food on which the animal subsists; and yet it is so strictly in accordance with each animal's organization, that an experienced anatomist can tell, by the inspection of this apparatus alone, the class to which the individual belongs.

141. Insects which masticate their food are furnished with jaws of a great variety of construction, and all admirably adapted for the service they are to perform. "Some are sharp, and armed with spines and branches for tearing flesh; others are hooked, for seizing, and at the same time hollow, for suction. Some are like shears, for gnawing leaves, and others more like grindstones, of a strength and solidity sufficient to reduce the hardest wood to powder."

142. Mastication, in most of the higher animals, is performed by means of teeth implanted in the jaws, and so arranged as to act against each other with a cutting, grinding, or chewing power, according to the nature of the food on which they operate.

143. In man and most of the mammalia there are three kinds of teeth, namely, *incisors*, *canine* and *molars*. The

How is the food divided when the process of digestion is performed rapidly? How do the organs of mastication indicate the class to which each animal belongs? What is said of the jaws of insects? How is mastication performed in most of the higher animals? How many kinds of teeth are there in man and the mammalia?

incisors have a thin cutting edge, intended simply to divide the food; the *canine* have a conical form, adapted to tearing it in pieces; the *molars* are formed for bruising or grinding the food.

144. There are also two sets of teeth—the temporary or *milk teeth*, and the *permanent teeth.*

Fig. 22.—DEVELOPMENT OF TEETH.—*a*, the gum; *b*, the lower jaw; *c*, dental capsules.

Fig. 23.—DENTAL CAPSULE.

145. The first set, or *milk teeth*, (*fig.* 22,) are twenty in number—four incisors in the front of each jaw, and two canine and four molar teeth on each side. All these teeth fall out at from six to eight years of age, and are gradually rēplaced by the permanent teeth, (*fig.* 23,) which are

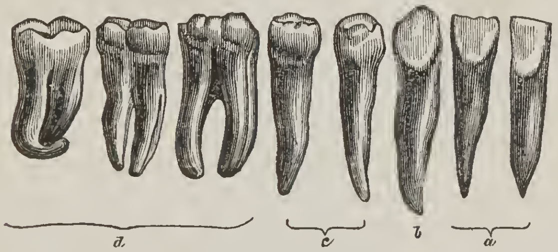

Fig. 23.—HUMAN TEETH.—*a*, incisors; *b*, canine tooth; *c*, bicuspid teeth; *d*, molars.

thirty-two in number, sixteen in each jaw, namely: four incisors, two canine, four bicuspids or small molars, and six true molars. The last molar does not make its appearance until long after the rest, and hence it is called the *wisdom-tooth.*

146. The human teeth are composed of three distinct

Describe each. How many sets of teeth are there? How many teeth are there in the first set? How many in the second? When does the last molar make its appearance? Of what are the human teeth composed?

structures—the *ivory* or tooth-bone, the *enamel*, and the *cementum.* The *ivory*, which constitutes the main part of of the tooth, resembles bone in its structure, except it contains a larger amount of mineral matter, and is harder than bone. The *enamel* forms a crust over the whole surface of the crown of the tooth, and protects it from wearing out or decaying. It is composed of ninety-eight parts in a hundred of mineral matter, and is the hardest of all animal substances. The cementum forms a covering to the root of the tooth, and serves to make its attachment in the jaw more firm. *Fig.* 24 represents a section of a human tooth.

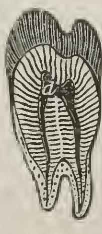

Fig. 24.—SECTION OF A HUMAN TOOTH.—*d*, dental cavity.

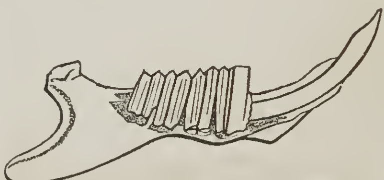

Fig. 25.—JAW AND TEETH OF RABBIT.

147. Other animals have the enamel distributed differently. The incisors of the rabbit and other rodentia or gnawing animals have the enamel on the front side of the tooth—the ivory being on the back part, is worn off first, leaving a sharp point of enamel, as represented in *fig.* 25. The continual wearing away of the incisors in this class of animals is provided for by their constant growth from below.

148. In the horse, ox, and other grass-eating animals, the enamel forms upright plates in the midst of the ivory which forms the main body of the tooth. The ivory being the softest, is worn away first, leaving the enamel in

Describe each structure of the teeth. How is the enamel distributed on other animals? Describe the incisors of a rabbit. Describe the teeth of grazing animals. What is said of the form of the teeth?

Fig. 26.—TEETH OF HERBIVOROUS ANIMAL.

projecting ridges, which are admirably adapted to the grinding action of the tooth. (*Fig.* 26.)

149. The particular form of the teeth of any animal corresponds with the nature of the food on which that animal subsists. In those which live entirely on animal flesh, the molar teeth are so compressed as to form cutting edges, which work against each other like a pair of shears. (*Fig.* 27.) In animals which live on insects, the molar teeth are raised into conical points, which lock into corresponding depressions in the teeth of the opposite jaw. (*Fig.* 28.)

Fig. 27.—TEETH OF CARNIVOROUS ANIMALS.

Fig. 28.—TEETH OF INSECT-EATING ANIMALS.

When the animal lives on soft fruits, these teeth are simply raised into rounded elevations. (*Fig.* 29.) When they are destined to grind harder vegetable substances, their surface is flat and roughened, as in those of the horse and ox.

Fig. 29.—TEETH OF FRUGIVOROUS ANIMAL.

150. In fishes and reptiles, the teeth are short and bent backward, and are thus adapted to seizing and retaining their prey, rather than dividing or tearing it in pieces. The head of the rattle-snake is represented by *fig.* 30. In the front part of the upper jaw are two

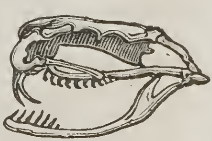

Fig. 30.—RATTLE-SNAKE.

What is the form of the teeth in animals which live on flesh?—on insects?—on fruits? What is the form of the teeth in fishes and reptiles?

poison fangs, consisting of hollow tubes, through which the poison secreted in the glands on each side of the head is injected.

151. The teeth are brought into action by means of the muscles, which move the lower jaw in a manner corresponding with the nature of the food. In flesh-eating animals, the lower jaw has a hinge-like action, opening and shutting like a pair of shears, and the sharpness of the teeth renders them a powerful cutting instrument. The jaw of the herbivorous animals has a lateral motion, by which the food is ground between the rough surfaces of the teeth. In the gnawing animals, the lower jaw is drawn rapidly backward and forward, and the teeth are thus made to act as a powerful file, by which the hardest shell is quickly rasped to a powder.

152. In man, we find a combination of each of the above movements. He can move the lower jaw upward and downward, from side to side, and forward and backward, and is thus adapted to the mastication of a mixed diet of all the endless variety of articles upon which he is accustomed to subsist.

INSALIVATION.

153. *Insalivation* is the act of blending with the food the saliva, which is a watery fluid secreted in the parotid, sublingual and submaxillary glands, and poured into the mouth during the process of mastication. The parotid glands are situated on each side of the cheek, just below the ear; the sublingual, under the tongue; and the submaxillary, near the angles of the lower jaw.

154. The use of the saliva is to make the food soft and moist, so that it can be more easily swallowed, and be rendered more solvent in the digestive fluid of the stomach.

How are the teeth brought into action? How does the lower jaw act in different animals? Describe the movements of the lower jaw in man. What is insalivation? Where are the salivary glands situated? What is the use of the saliva?

When the organs of mastication are at rest, only saliva enough is secreted to keep the mouth moist; but its flow is greatly increased when the movements of mastication commence, and when food is taken into the mouth. The sight or even the thought of food will frequently cause the saliva to be poured out more freely, making "the mouth water," as it is termed. During the progress of fever, the secretion of saliva ceases or is very much diminished, and the mouth becomes dry and parched.

155. If the food is imperfectly masticated, or is swallowed very rapidly, the saliva is also imperfectly mixed with the food, and the work of digestion becomes correspondingly more difficult. In this country, impaired digestion and loss of general health is a frequent result of rapid eating.

156. When mastication has been completed, the food is transmitted in successive portions to the stomach by the act of *deglutition* or swallowing. The food is first collected into a ball or mass by the action of the muscles of the cheeks and tongue, and is conveyed back against a sort of movable curtain (the vail of the palate), which hangs from the sides of the palate so as to touch the tongue by its lower border, and makes the mouth a closed cavity. (*Fig.* 31.) The instant the food is brought against this partition, it opens, and allows the food to pass into the pharynx. The œsophagus or food-pipe receives the morsel from the

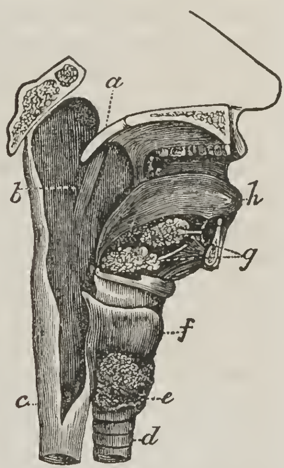

Fig. 31.—SECTION OF MOUTH AND THROAT.—*a*, vail of the palate; *b*, pharynx; *c*, œsophagus; *d*, trachea; *e*, thyroid gland; *f*, larynx; *g*, salivary gland; *h*, tongue.

When is the saliva secreted? How is the secretion of saliva affected by fevers? How is digestion affected by an imperfect mastication of the food? How is the food transmitted to the stomach?

pharynx, and forces it along to the stomach by the alternate contraction of its successive portions. The undulating movement produced by the contractions may be readily observed in the œsophagus of a horse while in the act of drinking.

157. The form and size of the stomach varies in different animals, according to the nature of the food to be digested. It is found in its simplest condition in the class of polypes, of which the hydra (*fig.* 14) is an example. In this animal, the stomach is merely a bag or sac with one opening, as represented in *fig.* 4, Pl. VII. Around this orifice to the stomach are from six to ten arms, for the purpose of seizing its prey, which is swallowed whole, and readily digested without any mechanical division whatever. In the planaria, (*fig.* 1, Pl. VII.) an animal of a little higher organization, numerous branches or canals pass off from the stomach to various parts of the body.

158. In all the higher orders, the stomach has two orifices, and is prolonged into a canal, as represented in *fig.* 5, Pl. VII., called the *alimentary canal.* In the carnivorous animals, whose food is flesh, which is easily dissolved, the stomach is very simple in its structure, and the alimentary canal comparatively short.

159. The most complex stomach and the greatest length of alimentary canal is found in ruminating animals—as the ox, sheep, deer, &c. In this class of animals, the stomach possesses four distinct cavities, as represented in *fig.* 32, which represents the stomach of a sheep. The food is at first imperfectly masticated in the mouth, and passed to the first stomach, to be macerated; it is then passed into the second stomach, where the fluids are received, and

What is said of the form and size of the stomach? In what class of animals is it found in its simplest condition? Describe the stomach of a hydra. What variation is found in the planaria? Describe the stomach of the higher orders of animals. In what class of animals is the stomach the most complex? How many cavities are there in the stomach of a ruminating animal? Describe the course of the food through the several cavities.

PLATE VII.

ORGANS OF DIGESTION.

FIGURE 1.——*Digestive Apparatus of a Planaria.—a*, Mouth, surrounded by a circular sucker. *b*, Buccal cavity. *c*, Orifice of the œsophagus. *d*, Stomach. *e*, Ramifications of gastric canals. *f*, Cephalic ganglia and their filaments.

FIGURE 2.——*Digestive Apparatus of a Fowl.—a*, Œsophagus. *b*, Crop. *c*, Second stomach, in which the gastric juice is secreted. *d*, Gizzard. *e*, Liver. *f*, Gall-bladder. *g*, Bile ducts. *h*, Pancreas. *i*, Duodenum. *k*, Large intestine—its two cæca, *l*.

FIGURE 3.——*Digestive Apparatus of a Beetle—a*, The head and jaws. *b*, Crop. *c*, The gizzard. *d*, The true digestive stomach, surrounded hy its follicles. *e*, The long vessels which constitute a rudimentary liver.

FIGURE 4.——*Ideal Representation of the Simplest Form of a Stomach*, as found in the hydra.

FIGURE 5.——*Ideal View of the Alimentary Canal*, as found in the higher orders of animals.

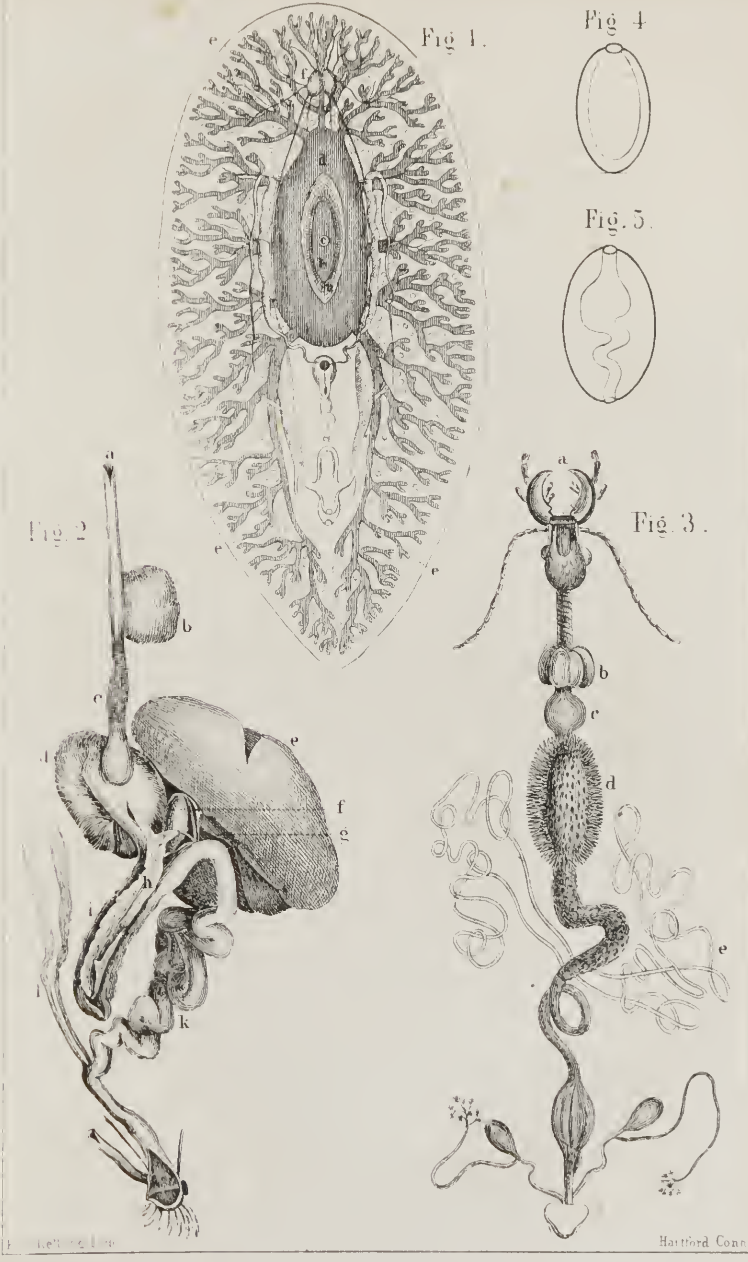
Fig 1.
Fig 4
Fig. 5.
Fig. 2
Fig. 3.
a
b
c
d
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rolled into a small ball, to be returned to the mouth, and undergo a second process of mastication, called "chewing the cud." When the food is again swallowed, it is passed into the third and thence into the fourth stomach to go through the final process of digestion.

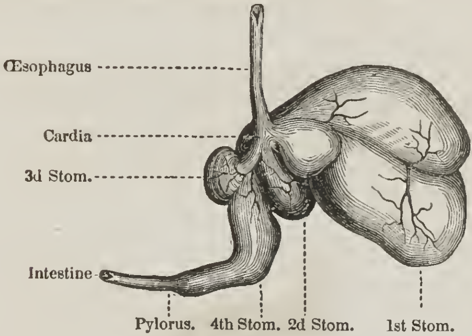


Fig. 32.—STOMACH OF THE SHEEP.

160. Birds, which have no means of masticating their food, are provided with a peculiar modification of the stomach. In those which live on grain—as the common fowl, quail, &c.—the food is first moistened and softened in the crop, just as it is in the first stomach of the sheep. It is then passed through a second stomach (where it is saturated with the gastric juice) into the gizzard. In the gizzard, it undergoes a triturating or grinding process, which is accomplished by means of pieces of quartz or other angular stones, which the bird instinctively swallows for the purpose, and the strong muscular action of the organ. The digestive apparatus of a fowl is represented in *fig.* 2, PL. VII.

161. A powerful gizzard is also found in most insects, but it is placed above the digestive stomach instead of below it, as in birds. In *fig.* 3, PL. VII., is represented the digestive apparatus of a carnivorous beetle.

How is the stomach modified in birds? How is the gizzard placed in insects?

162. By a comparative view of the structure of the stomach in the different groups, we cannot fail to observe a regular gradation, from the simple digestive sac of the hydra to the complex apparatus of the ruminating animals. In man, the stomach is intermediate between the carnivorous and herbivorous mammalia, and is very clearly adapted to a mixed diet.

163. The stomach in man is an oblong membranous bag, placed obliquely across the abdomen, and just below the diaphragm. Its average capacity in the adult is about one quart, though it may be distended to contain a much larger quantity, or be contracted to a very small size. It has two openings—one towards the heart, called the *cardiac orifice*, which receives the food from the œsophagus—and the other at the right or small end of the stomach, called the *pyloric orifice*, for the transmission of food to the small intestines. The form of the stomach and the position of its openings are represented in *fig.* 33.

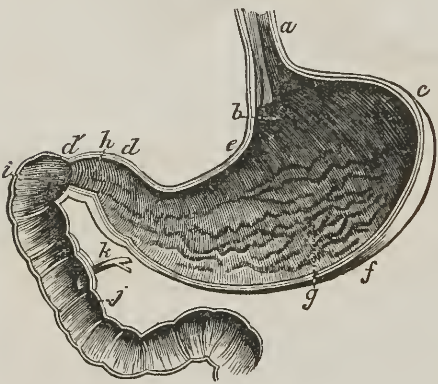


Fig. 33.—A SECTION OF THE STOMACH.—*a*, the œsophagus; *b*, the cardiac orifice; *c*, the great end of the stomach; *d*, its lesser or pyloric end; *d'*, the pyloric orifice; *e*, the lesser curve; *f*, the greater curve; *g*, the rugæ or wrinkles of the mucous membrane; *h*, the pylorous; *i*, *j*, the duodenum, or first portion of the small intestine; *k*, the duct through which the bile and pancreatic juice are poured into the duodenum.

164. The stomach possesses three coats—the outer or *serous*, the middle or *muscular*, and the inner or *mucous* coats.

What do we observe by a comparative view of the stomach in different animals? Describe the human stomach. How is it placed? What is its average capacity in the adult? How many openings has it, and what are they called? How many coats does the stomach possess, and what are they?

165. The *serous* coat is the same as the external coat of all the organs which are not exposed to the air. Its use is to secrete a fluid which lubricates the surface of the organs, and prevents friction between them.

166. The *muscular* coat is composed of numerous muscular fibres, such as we see in lean meat. These fibres possess great power of contraction, being drawn up and stretched out again like India-rubber without injury. Some of these fibres run lengthwise of the organ, some wind around it in the form of rings, and others run obliquely across it. By the alternate contracting and relaxing of these fibres, a great variety of motion is produced during the process of digestion, causing the food to be rolled about and moved successively over every portion of the inner or mucous coat. In the act of vomiting, there is a spasmodic contraction of all the fibres, throwing the contents of the stomach back into the mouth.

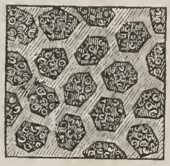


Fig. 34.—Mucous Membrane of the stomach magnified, showing the cells, with the mouths of tubes open at the bottom of each.

167. The *mucous membrane* (*fig.* 34) lines the inside of the stomach with a very soft and velvety investment. It is not elastic, like the other coats, but is drawn into folds when the stomach is contracted, and spreads out smoothly when it is dilated. This coat secretes a mucous or slimy matter, which protects the stomach from being unduly irritated by its contents, and it also pours out from numerous little follicles or glands the *gastric juice*, in which the food is dissolved.

168. The gastric follicles perform an important part in the process of digestion. They are of a tubular form, as represented in *fig.* 35, from $\frac{1}{500}$th to $\frac{1}{300}$th of an inch in diameter. When there is no food in the stomach, these

Describe the serous coat of the stomach—the muscular coat—the mucous coat. What does the mucous coat secrete? What is secreted by the gastric follicles? What is the use of the gastric juice? Describe these follicles.

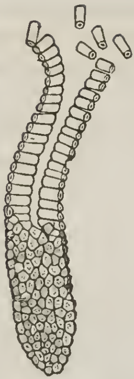


Fig. 35.—ONE OF THE TUBULAR FOLLICLES OF THE STOMACH, MAGNIFIED.

follicles or glands are at rest; but immediately on the introduction of food, they commence secreting actively an acid fluid, which exudes in drops, running down the walls of the stomach, and soaks into the substances within it.

169. The *gastric fluid* is a very powerful solvent of all proper food of every kind, whether animal or vegetable. It is indispensable to digestion, and is found no where but in the living stomach.

170. The amount of gastric fluid secreted at one time, corresponds with the quantity of food which is then needed by the body as nourishment. It begins to flow as soon as the first mouthful of food is introduced into the stomach, and continues to be poured out till the demand for nourishment is supplied, and then ceases. If more food be taken than is sufficient for the wants of the system, it will remain undigested, and become a source of irritation and oppression; or, being mixed with that previously received into the stomach, the digestion of the whole is retarded.

171. The sense of hunger is felt when there is a demand for a fresh supply of nourishment, and the stomach is in a condition to pour out its secretion. If the food be then swallowed no faster than the gastric fluid is prepared to be mixed with it, hunger or the desire for food will cease when the secretion ceases, or when just food enough has been taken; but if the food be swallowed twice as fast as it can be supplied with gastric juice, the sense of hunger will continue till twice as much is taken as is actually re-

How does the gastric juice act on all kinds of food? With what does the amount of gastric juice correspond? When is it secreted? How is the food disposed of when more is taken than is required? When is the sense of hunger experienced? When does it cease to be felt? What is the consequence of swallowing the food twice as fast as it should be?

quired. Hence, rapid eating creates an unnatural appetite, frequently causing nervous irritability, and dyspepsia or disease of the stomach. In this country, where men are governed more by the excitement of business than by any regard to health, rapid eating is a prevailing sin, the consequences of which are apparent in a greater proportion of dyspeptic complaints than are to be found in any other country.

172. When the proper kind of food has been taken in proper quantities, the fibres of the muscular coat of the stomach alternately contract, pressing the mass of food *backward* and *forward*, and from side to side, exposing every part of it to the action of the gastric juice, until its solution is complete. This process lasts from two to five hours, or even longer, according to the kind of food and the thoroughness with which it has been masticated. The agitation of the food is assisted by the action of the respiratory organs, in alternately raising and depressing the diaphragm whenever the air is inhaled or exhaled from the lungs.

173. "The readiness with which the gastric fluid acts upon the several articles of food is in some measure determined by the minuteness of division, and the tenderness and the moisture of the substance presented to it. By minute divisions of the food, the extent of surface with which the digestive fluid can come in contact is increased, and its action proportionably accelerated." Hence, when the food is thoroughly masticated, it digests with greater facility. Tender and moist substances also digest more easily than those that are tough, hard, and dry; because they are more easily as well as more thoroughly penetrated by the gastric fluid.

174. The value of any particular substance, as an article

What evils result from rapid eating? Describe the manner in which the food is moved backward and forward in the stomach. How long does this process last? What circumstances facilitate the action of the gastric juice on the food?

of diet, is not in all cases in proportion to its digestibility; for many substances that are easily soluble in the gastric fluid afford only a small amount of nourishment, while others that are more difficult of solution are highly nutritious. Fresh fish, for instance, may be digested in less than half the time required for beef-steak, though the beef-steak is decidedly the most nutritious. A substance, to be nutritive, must not only contain an abundance of those elements which go to form the tissues of the body, but it must be capable of being digested by the gastric fluid or some other secretion in the alimentary canal, and of being assimilated to the blood.

175. When digestion is completed in the stomach, the food and gastric juice are thoroughly mixed, and converted into a pulpy mass, called *chyme*. There are many circumstances, besides the nature of the food, which affect this process.

176. Only a sufficient quantity of food should be taken to fairly fill the stomach, and not to distend it.

177. Sufficient time should elapse after each meal to allow the stomach to become empty before a fresh supply is taken. This interval in adults should generally be five or six hours, though it varies with the kind of food, the condition of the stomach, and the constitutional peculiarities of each individual. In young persons, where all the functions are performed with more activity and vigor, the intervals between the meals may be much shorter than in adults.

178. Gentle exercise, both before and after each meal, is favorable to digestion; while excessive exertion, whether bodily or mental, retards it.

Is the value of a particular article of diet in proportion to its digestibility? What properties do render an article of diet nutritive? What is the food converted into when digestion is complete? What should be the quantity of the food? What time should be allowed between each meal? Why should the intervals between the meals be shorter with young persons than with adults? How does exercise affect digestion?

PLATE VIII.

ORGANS OF DIGESTION.

FIGURE 1.——*General View of the Digestive Organs of Man.*—This figure is intended to give a general idea of the forms and relative positions of the organs of digestion.—*a*, The œsophagus. *b*, The stomach. *c*, The duodenum. *d*, *d*, *d*, Convolutions of the small intestine. *e*, The cœcum. *f*, Appendix of the cœcum. *g*, Opening of the small into the large intestine. *h*, The ascending colon. *i*, *i*, Transverse arch of the colon. *j*, The descending colon. *k*, The liver. *l*, The gall-bladder. *m*, The pancreas, mostly covered by the stomach. *o*, The spleen.—In this figure, the liver is raised up and the transverse arch of the colon drawn down, in order to show parts which they cover when in their natural situation.

FIGURE 2.——*General Aspect of the Abdominal Viscera.*—In this figure, the anterior walls of the abdomen are removed, so as to show the organs in their natural positions. The small intestine is removed.—*a*, The liver, situated beneath the right arch of the diaphragm. *b*, The stomach. *c*, Epiploa, or floating folds of the peritoneum. *d*, Summit of the gall-bladder. *e*, *e*, Large intestine, showing all its courses.

FIGURE 3.——*The Chyle-Vessels and the Thoracic Duct.*—*a*, A portion of the small intestine. *b*, *b*, Origins of lacteals. *c*, Mesentery. *d*, Mesenteric glands. *e*, Lymphatic vessels. *f*, Thoracic duct. *g*, Aorta. *h*, Thoracic duct, curving downward and forward, to empty its chyle at the junctions of the left jugular and sub-clavian veins.

FIGURE 4.——*The Pancreas.*—This figure is given to show more clearly the situation and connexions of the pancreas. *a*, The pancreas. *b*, The duodenum. *c*, The gall-bladder. *d*, Duct of the gall-bladder, which communicates with the hepatic duct, *e*, which leads from the liver. *f*, Duct of the pancreas, which opens into the common bile-duct, *g*, through which the combined secretions of the pancreas and the liver are poured into the duodenum.

FIGURE 5.——*The Liver.*—Section of the liver, showing the ramifications of the vessels. The hepatic vena portæ is a division of the abdominal vena portæ, into which empty all the veins of the digestive organs. It sends branches into all parts of the liver. After these branches have reached the capillary state, they are succeeded by the roots of the hepatic veins, which unite into three large veins which empty into the inferior vena cava. *a*, The right or greater lobe. *b*, The left or smaller lobe. *c*, Groove which lodges the umbilical vein. *d*, Hepatic vena portæ. *e*, Hepatic artery. *f*, Inferior vena cava.

FIGURES 6 and 7.——*Liver.*—Figure 6 represents a horizontal section of two superficial lobules of the liver, showing the probable arrangement of the biliary ducts. *a*, *a*, Inter lobular branches of the hepatic veins. *b*, *b*, Trunk of biliary ducts.

FIGURE 7 represents a horizontal section of three superficial lobules, showing the two principal systems of blood-vessels. *a*, *a*, Inter-lobular veins proceeding from the hepatic veins. *b*, *b*, Inter-lobular plexuses formed by branches of the portal veins.

PL. VIII.

Fig. 1.

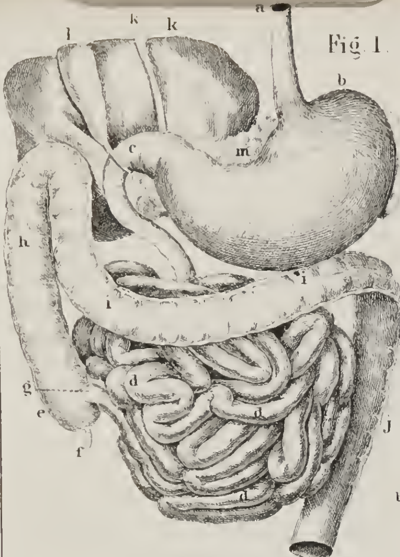


Fig. 3.

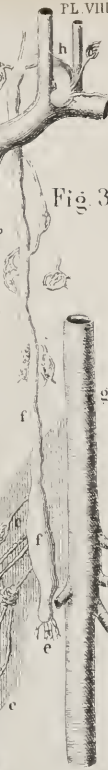


Fig. 6

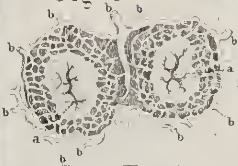
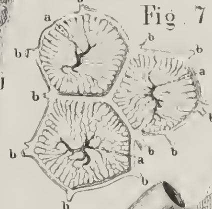


Fig. 7



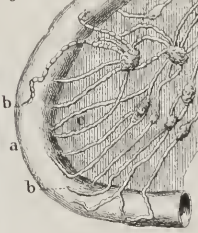


Fig. 2.

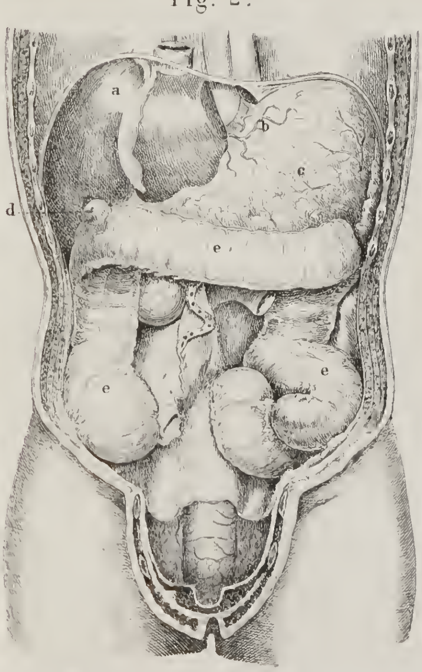


Fig. 4

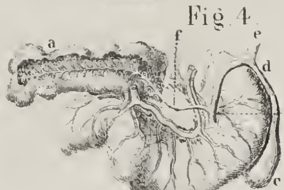


Fig. 5

E. C. Kellogg Lith. Hartford Conn.

179. A quiet and tranquil state of mind is also essential to good digestion.

180. Drinks taken in large quantities materially interfere with the process of digestion. The juices secreted by the stomach itself are sufficient for the solution of most articles of diet; and whenever a superabundance of liquid is swallowed, the first effort of the stomach is to get rid of it. This it does by absorbing the liquid at once and without change through the blood-vessels of the mucous coat. The digestion of the more solid materials is not commenced until the liquid is disposed of.

181. As soon as any portions of the food become sufficiently digested to mix with the gastric fluid, and form chyme, they are sent through the pyloric orifice of the stomach into the duodenum, or first portion of the alimentary canal. (*Fig.* 33.) Around the pyloric orifice (*d*), at the inside, is a thick band or valve, called sphincter. When digestion is not going on, this sphincter, as well as a similar one at the cardiac orifice (*b*), is so completely closed that none of the contents of the stomach can escape. But towards the termination of the digestive process, the pylorus offers less resistance. First it yields to allow the successively digested portions to go through it, and afterwards it allows the passage of even undigested portions, which are always retained in the stomach much longer than those portions that are readily digested, and produce the irritability and suffering so often experienced after eating indigestible substances.

182. In the intestinal or *alimentary canal* the food is further acted upon, and undergoes other changes.

183. The *alimentary canal* is divided into two portions, named, from their difference in diameter, the *small* and the

What effect has the mind on digestion? How do drinks affect digestion when taken in large quantities? How does the stomach get rid of the fluids? What course does the food take when it has become sufficiently digested to form chyme? Describe the pyloric orifice of the stomach. Into how many portions is the alimentary canal divided?

large intestines. This distinction is much less marked in carnivorous animals than in those which feed on vegetables, and the length of the canal differs greatly in the two orders. In the tiger, for instance, the intestines are about three times the length of the body. In the sheep, they are about twenty-eight times longer than the body, or seven times as long as those of the tiger in proportion to the size of the animal. In those animals which live on a mixed diet, the intestines are of a medium length. In man, they are about six times the length of the body.

184. The small intestine, which commences at the pyloric orifice of the stomach and terminates in the large intestine, is about twenty-five feet in length in man, is a narrow tube with thin walls, and is coiled in various directions, as represented at *d*, *fig.* 1, Pl. VIII.

185. The large intestine, or colon, is about five feet in length, and resembles in appearance a long sac divided into numerous pouches.

186. The intestines, like the stomach, have three coats—the peritoneal or serous, the muscular, and the mucous. The mucous membrane of the small intestine is found in transverse folds, which greatly increase the extent of its surface.

Fig. 36.—Single Gland of Small Intestine.

187. In the substance of the mucous membrane, glands are imbedded, one of which is represented in *fig.* 36, and the surface is studded with minute processes, termed *villi.*

188. Through these villi the nutritive portion of the digested food is absorbed, and conveyed by a set of vessels, called *lacteals*, into the general circulation.

189. After the chyme or digested food has passed out

What is the length of the alimentary canal in the tiger?—in the sheep?—in man? Describe the small intestine—the large intestine. How many coats have the intestines? What glands are imbedded in the mucous membrane of the intestine?

of the stomach into the small intestine, it becomes mixed with the bile secreted by the liver, and with the juice secreted by the pancreas or sweet-bread.

190. The pancreas is a long narrow gland, situated partly behind the right side of the stomach, and within the first curve of the small intestine, as represented at *m*, *fig.* 1, Pl. VIII. The fluid which it secretes seems to be of a nearly similar nature with saliva, and is supposed to assist in digesting fatty substances, and rendering them fit for absorption.

191. The liver is the largest gland in the body. It is situated in the right side, below and in contact with the diaphragm, and is divided into several lobes. At its lower side is the gall-bladder, into which the bile is poured, after being secreted. The gall-bladder thus serves as a reservoir to the bile. Its duct opens into a duct leading direct from the liver, and forms with it the common bile-duct, through which the bile is poured into the small intestine at the same point with the duct from the pancreas. These ducts are represented in *fig.* 4, Pl. VIII.

192. The bile is a greenish-yellow fluid, having an extremely bitter taste and a nauseous smell. It is constantly secreted by the liver; but, during fasting, it accumulates in the gall-bladder, whence it is poured out on the introduction of food into the stomach.

193. By the mingling of bile and pancreatic juice with the chyme in the small intestines, chyle is formed. The chyle is a whitish milk-like fluid, with a somewhat saltish taste. It is, in fact, imperfectly-formed blood, and nearly resembles blood in its constituent parts. The chyle is absorbed as the digested food passes along through the small intestine. The residue of the chyme, consisting of indi-

What changes does the food undergo after passing out of the stomach? Describe the pancreas. What is supposed to be the use of the fluid secreted by the pancreas? Describe the liver. How is the gall-bladder situated? What are the properties of the bile? How is the chyle formed? How is it absorbed?

gestible substances, gradually becomes more and more dry and hard, till it is at length carried into the large intestine, and thence excreted from the system.

194. The food and the several secretions mixed with it are carried through the intestinal canal, and slowly exposed to the action of the absorbent vessels by the peristaltic or vermicular movements of the intestines. This movement is effected by means of the successive contractions and dilations of the intestinal coats, which extend in a wave-like manner throughout the tube. In health, this movement is slow, and generally unperceived by the mind; but it becomes very perceptible in diarrhea, or when accelerated by the influence of purgatives.

195. The natural movements of the bowels are indispensable to the continuance of health, and they should not be restrained by tight waist-bands or ligatures around the body. The habit of wearing garments that are too tight is a frequent cause of inactive or constipated bowels, and finally leads to impaired health and disease.

What movements force the passage of the food along the alimentary canal? What effect does the wearing of tight garments have on the natural movements of the bowels and on health?

CHAPTER VII.

ABSORPTION.

196. ABSORPTION is that process by which all the various elements of the body are taken into the circulation.

197. All the tissues of the body, except the enamel of the teeth, and some of very low organization, as the hair and nails, possess to some degree the power of absorption.

198. Fluids are absorbed most readily, and none are absorbed with so great facility as water. A large proportion of the weight of the body is due to the water which its tissues absorb. Muscle, in drying, loses three-fourths of its weight, and blood four-fifths. Mummies have been found of adult size with all the organs entire, but reduced, by the evaporation of the watery fluids, to a weight not exceeding eight pounds.

199. The process of absorption is performed throughout all the tissues by two sets of vessels, viz: the *lymphatics* or *lacteals* and *blood-vessels.*

200. The *lymphatics*—a portion of which are also *lacteals*—constitute a peculiar and distinct system of vessels, which are distributed to every part of the body where there are blood-vessels. The lymphatics derive their name from the peculiar limpid fluid or lymph which they convey.

201. Those which have their origin in the mucous membrane of the alimentary canal have received the name of lacteals, from the milky appearance of the chyle which they absorb.

202. The lymphatics are minute and delicate vessels, with walls so thin that they are nearly invisible unless

What is absorption? What tissues possess the power of absorption? To what is a large portion of the weight owing? How much of its weight does muscle lose in drying?—and blood, how much? To how small a weight have mummies been found reduced? By what vessels is the process of absorption performed? What are the lymphatics? From what do lymphatics derive their name? What are the lymphatics called that have their origin in the mucous membrane? Describe the lymphatics.

distended with some colored substance. They commence in closely meshed net-work, or in loops distributed upon the external surface of all the organs, and interspersed among the proper elements and blood-vessels of all the several tissues.


Fig. 37.—LYMPHATICS.

203. Externally the lymphatics present a constricted or knotted appearance, owing to the existence of numerous valves, formed by semi-circular folds of the lining membrane, arranged in pairs, (*fig.* 37,) and their edges coming together so as to prevent the flow of fluids, except in the direction towards the heart. By this arrangement, all muscular or external pressure accelerates the flow of lymph, as it does that of the blood in the veins. In reptiles and some birds the flow of the lymph is effected by muscular sacs, called lymph-hearts.

204. The *lymphatic* glands are small, oval, and somewhat flattened or rounded bodies, composed of a plexus of minute lymphatic vessels, and a plexus of blood-vessels convoluted or twisted upon each other, and inclosed in a thin cellular capsule, in such a manner as to form small knots or kernels, as they are sometimes called, when they become inflamed and swollen. In scrofulous persons, these glands are exceedingly liable to become enlarged, particularly on the sides of the neck and in the armpits.

205. The contents of the lymphatics pass through the lymphatic glands, and undergo a process of digestion, by which they are renovated and fitted for further use in the animal economy.

206. The *lacteals*, or lymphatics of the alimentary canal, commence in the villi of the mucous membrane, as repre-

How do they commence? What is the appearance of the lymphatics externally? How are the valves formed? Of what use are the valves? How is the flow of lymph effected in reptiles? What are lymphatic glands? What are they sometimes called when they become inflamed? How are the contents of the lymphatics affected by passing through these glands? How do the lacteals commence?

sented in *fig.* 38. Each villus resembles in appearance a minute papilla or point in the mucous membrane, and is formed of an extremely delicate membrane, termed epithelium which contains a plexus of lacteals, all forming a fine network in the submucous tissue, (*fig.* 39.) Each villus sends forth only one lacteal vessel, and this so small as to be imperceptible to the naked eye.

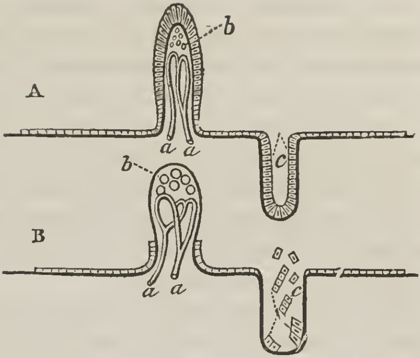


Fig. 38.—DIAGRAM OF MUCOUS MEMBRANE.—A, in the intervals of digestion; B, during digestion; *a*, *a*, absorbent vessels; *b*, *b*, absorbent cells of a villus; *c*, *c*, pits or follicles between the villi.

207. As the lacteals issue from the villi, they unite to form large trunks, and, passing through the mesenteric glands, join in one common trunk the *thoracic duct*, and may thus be compared to the roots of a tree, which commence in numberless minute fibres in the soil, and finally join to form its main trunk, the body of the tree.

Fig. 39.—APPEARANCE OF LYMPHATICS IN THE MUCOUS MEMBRANE OF THE STOMACH.—*a*, superficial layer; *b*, deep layer.

208. The *thoracic duct* is the main trunk, into which the contents of the lymphatics and lacteals are emptied. It commences in front of the second lumbar vertebra, and passes up in front of the back-bone to discharge its contents by a valvular opening into the large vein just beneath the clavicle or collar-bone.

Describe a villus. What do the lacteals unite to form? Through what glands do the lacteals pass? Describe the thoracic duct. Into what does the thoracic duct discharge its contents?

209. Absorption by lymphatics or lacteals takes place through the walls or coats of the vessels, and these are so constituted that only those materials which are suited to form lymph and chyle can traverse them. This system of vessels therefore possesses the remarkable property of selecting those elements which are in a state of organization to fulfil certain specific purposes in the animal economy, and all others are rejected. Hence, the lymph and chyle invariably present nearly the same characteristics and contain the same elements.

210. But blood-vessels do not seem to possess any such power of selecting materials as has been attributed to lymphatics and lacteals; for any substance, whether gaseous, liquid, or a soluble, or a minutely divided solid, may be absorbed by a blood-vessel provided it is capable of permeating its walls.

211. In the alimentary canal, the fluids are taken up by the veins, and the more solid materials by the lacteals.

212. From the skin, absorption is performed mainly by the veins, though it is a well-known fact that various poisonous and medicinal substances take effect through the lymphatics. When irritating substances are rubbed on the skin, red streaks soon appear in the course of the lymphatics, and the lymphatic glands become swollen and inflamed. In like manner, poisonous substances acquired through slight wounds, such as are received in dissecting dead bodies in a certain state of decomposition, or by the sting of insects or by the bite of reptiles, extend along the course of these, and produce fatal consequences.

213. There are peculiar conditions of the body in which

How does absorption by lymphatics or lacteals take place? What materials can traverse the walls of the lymphatics? What remarkable property does this system of vessels possess? Do blood-vessels possess any power of selecting materials? What substances may be absorbed by blood-vessels? How are substances taken up in the alimentary canal? How is absorption performed from the skin? How are poisons known to take effect? Under what circumstances does absorption from the skin take place with great activity?

the absorption of fluids through the skin is performed with very great activity. Persons who are suffering from thirst, receive great relief by applying water to the skin. When the natural amount of fluids in the body has been diminished by excessive perspiration, or by long abstinence from fluids, the weight of the body may be increased several ounces or pounds by immersion in a warm bath.

214. It is on account of the increased activity of the absorbents that contagious disease is acquired more easily after fasting than after a full meal. Fear, anxiety of mind, as well as every thing that depresses the tone and vigor of the system, renders it more susceptible to disease through the increased activity of the absorbents. Hence, epidemics that are propagated by an impure state of the atmosphere are most fatal among those who have the most dread of disease, and thus a quiet mind and an easy conscience are the best safeguards against contagious disease.

215. The necessity for a constant supply of food arises from the continual decomposition which is taking place in the living body. By this process, materials for nutrition are all the while set free, which it is the special office of the lymphatics to take up and pass through a kind of second digestion, thereby fitting them for further use in forming the tissues of the body. By this process of interstitial absorption, animals may live for a long time on their own solids. Hibernating animals, for instance, which retire to their winter-quarters loaded with fat, gradually become lean, and spend from four to five months of the year with no supply of nutriment, except such as is

Why are contagious diseases acquired more easily after fasting than after a full meal? What causes render the system more susceptible to disease? Among what class of persons are epidemics most fatal? What are the best safeguards against contagious diseases? What creates a necessity for a constant supply of food? What materials are taken up by the lymphatics? How may animals live for a long time on their own solids? What is said in regard to hybernating animals?

derived from the enormous quantities of fat which they lay in store during the period of their activity.

216. The mucous membrane is the most important channel through which all the new materials for the nourishment and growth of the body are introduced. The more nutritive portions are taken up chiefly by the lacteals, while liquids are absorbed by the veins.

217. In the lowest tribes of animals, and in the earliest condition of the higher groups, absorption by the skin seems equally important to the maintenance of life with that which takes place from the digestive cavity.

CHAPTER VIII.

NUTRITION.

218. Nutrition is that vital process by which the alimentary materials are converted into organized tissue. It consists essentially in a deposition in each tissue of the body of those elements which maintain its life and growth.

219. It is the function of the digestive organs to prepare from the food the elements of nutrition. By the process of absorption, they are taken from the digestive cavity, and emptied through the thoracic duct into the large vein, and thence into the right side of the heart, to be passed through the lungs into the left side, and from thence distributed by the arteries to all parts of the body.

220. The peculiar process by which the nutritive elements of arterial blood are formed into tissues, is called nutrition. But it is very evident that this process is dependent for its perfection upon other circumstances. There must not only be an abundant supply of nutritive

Through what channel are the materials for the nourishment and growth of the body chiefly taken up? What portions are taken up by the lacteals, and what by the veins? What is said in regard to absorption by the skin? What is nutrition? In what does nutrition essentially consist? By what organs are the elements of nutrition prepared? How are the elements of nutrition taken up? What circumstances may be regarded as essential to nutrition?

food, but the food must be well digested; the absorbents must transfer its nutritive portions to the general circulation. The heart and lungs must also perform their functions properly. If there is a failure in any of these particulars, the body cannot be perfectly nourished. Hence, it not unfrequently happens that the causes of deficient nutrition are not easily comprehended. Appetite, digestion, absorption, respiration, and circulation, may all be regarded as indispensable to a healthy nutrition.

221. The tissues of the body are constantly undergoing a series of rapid changes, in which the particles are decomposed and removed, to be rēplaced by new ones, which in their turn die and pass away. Yet every atom removed is supplied with a new one, so perfectly resembling the original, that the identity of an adult person is maintained through a series of years with the same form, size, and features, and in many instances the same weight, when perhaps not a particle of the original matter that constituted his body is retained. Each part and organ exactly maintains its form and composition during the successive changes of many years.

222. Each individual particle or atom has its own period of life, which is long or short according to the character of the tissue in which it is found. In muscle, for instance, it is supposed the changes are much more frequent than in bone. The milk-teeth exist for a limited period, and are then partially absorbed, and fall out, to be rēplaced by a more permanent set. The hair of quadrupeds, the feathers of birds, and the antlers of deer, are shed and rēproduced annually with nearly the same form, color, &c.

223. It is supposed that every action of any of the parts of the body is attended with a change of particles. When

What changes are the tissues constantly undergoing? How are the particles removed from the body supplied? What is said of the life of each individual particle? In what tissue are the changes the most frequent? What takes place with every action of any part of the body?

we move an arm, for instance, some of the atoms in the muscles which produce the motion die, and leave their places, being rēplaced by others.

224. The rapidity of the changes may also be supposed to be in proportion to the activity of the parts. In those who take much exercise, the atoms which compose the body must be changed much oftener than in the indolent and sedentary. In the same manner, the exercise of particular limbs will cause them to appropriate a much larger amount of nutritive matter. An individual who walks much, will therefore develop more fully the muscles of the lower limbs; while the blacksmith will develop more fully the muscles of the arms. But a palsied limb, which has fallen into disuse, will emaciate and grow smaller.

225. Physiologists have never been able to determine with certainty by what means each tissue selects from the blood just those elements which form its own composition. We must therefore regard it as one of those ultimate facts in nature, which lie beyond the limits of our present knowledge.

226. It is supposed, however, "that the process of nutrition consists in the growth of individual cells composing the fabric, and that these derive their support from the organic compounds with which they are supplied by the blood, and that the structure composing every separate portion of the body has what may be termed a special affinity for some particular constituents of the blood, causing it to absorb from that fluid, and convert into its own substance, certain of its elements."

227. When the amount of alimentary materials converted into tissue exceeds the waste of the decaying ele-

How is this illustrated by a movement of the arm? The rapidity of the changes are in proportion to what? What is the effect of exercising particular limbs? Have physiologists been able to determine the means by which each tissue selects those elements which form its own composition? In what is the process of nutrition supposed to consist? When is the body said to increase in size?

ments, the body is said to grow old, or increase in size. When the nutrition is less than the loss by decomposition, the body becomes emaciated. In the earlier periods of life, nutrition goes on rapidly, speedily producing the renewal and growth of the various parts of the body. When the body has attained its full size, the process of nutrition becomes less active as life advances. In middle life, nutrition just equals the loss by decomposition; in old age, the body becomes so imperfectly nourished, that it is literally worn out with years.

CHAPTER IX.

SECRETION.

228. Secretion is the process in plants and animals by which various materials are separated from the circulating fluid. From the sap of different plants, in which chemical analysis cannot detect the slightest difference, the most opposite and varying products are elaborated. Thus, the sap of the poppy produces the narcotic opium; that of the cherry-laurel, the deadly prussic acid; that of the olive, its oil. Acids are obtained from some; alkalies, from others; sweet juices, nutritive principles, oils, and resins, from others; different secretions are obtained from different parts of the same plant. In animals, the nutritious milk is secreted in one organ; bile in another; mucus, saliva, urine, &c., in others; and yet we are wholly ignorant of the reasons why, by the same process and out of the same fluid, so many different secretions are formed. All that we know is in regard to the structure of the organs concerned in elaborating those various secretions.

When is it said to become emaciated? How does the activity of nutrition vary at different periods of life? What is secretion? What is said of the secretions obtained from the sap of plants? What are some of the secretions obtained from the sap of plants? What are some of the secretions obtained from animals?

229. The process of secretion, both in the animal and in the plant, is performed by cells, which are arranged in different methods, according to the structure of the organ in which they are found. Those cells seem to have the power of separating the peculiar secretion of each organ from the blood of the membrane with which they are connected. At parts where it is necessary that the secretion should be particularly abundant, the secreting surface is increased by great numbers of little bags or follicles lined with cells.

230. There are two kinds of materials which are secreted from the blood of man, namely, those which go to form such products as may serve some useful purpose in the animal economy, called *secretions*, and those which would be injurious, if retained in the system, called *excretions*.

231. The two principal divisions of the secreting apparatus are membranes and glands. The principal secreting membranes are the serous and mucous membranes and the skin.

232. The serous membrane forms closed sacs, which envelop all the organs of the body not exposed to the air, and also line the cavities in which those organs are contained. The brain, heart, lungs, and the organs inclosed in the abdomen, are all protected by this membrane. A gaseous fluid is constantly secreted by it, which makes its surface smooth and moist, so as to render the movements of the organs free and easy, and prevent any friction where the surfaces come in contact with each other.

233. A peculiar variety of the same membrane is found at the ends of the bones, which secretes a thick fluid to lubricate the joints, called synovial fluid, from its resemblance to the white of an egg.

How is the process of secretion performed in animals and in plants? What power do the cells seem to possess? How is the secreting surface increased in particular parts? What two kinds of materials are secreted from the blood of man? What are the principal divisions of the secreting apparatus? What organs are protected by the serous membrane? What is secreted by the serous membrane? How are the ends of the bones protected?

234. The mucous membrane lines all those passages which communicate with the air—as the nose, the larynx, the bronchi and their minute ramifications in the lungs, and the whole digestive apparatus—from the mouth through the intestines. It secretes a peculiar viscid fluid, called mucus, which serves to moisten and defend this membrane, and aid in the exercise of smell and taste. When the mucous membrane becomes irritated or inflamed, as in common colds, causing catarrh, or in diarrhea and dysentery, it secretes a large amount of mucus, which sometimes becomes quite thick and hard, like the white of an egg when boiled or hardened by alcohol.

235. The most important of the secreting *glands* are the *liver*, the *kidneys*, the *salivary* and *lachrymal* glands.

236. The *liver* is found in some form in nearly all animals which possess a digestive cavity. In man and the mammalia, it is made up of a vast number of minute lobules, of irregular form. Each lobule contains a mass of cells, and a plexus of biliary ducts, with three blood-vessels; namely, the hepatic artery, the portal vein, and the hepatic vein. (*Figs.* 5 and 6, Pl. VIII.)

237. The hepatic artery furnishes nourishment to the substance of each lobule; the portal vein provides blood for the secreting operation; and the hepatic vein carries back the blood derived from both sources. The bile is taken up from each lobule by the plexus of biliary ducts which finally unite into a common duct.

238. The function of the liver in secreting bile is of very great importance to health. When the liver becomes inactive, or ceases to perform its office perfectly from any

What passages are lined by the mucous membrane? What is the secretion of the mucous membrane called? What is its use? What are the most important of the secreting glands? In what animals is the liver found? Of what is the liver made up in man and the mammalia? What does each lobule contain? Describe the use of the hepatic artery—the portal vein—the hepatic vein. How is the bile taken up from each lobule? What is said of the function of the liver? How is the health affected by inaction of the liver?

other cause, the health very soon becomes impaired, causing head-ache, languor, and nausea, if not more serious disease. The object of the secretion of bile is to separate from the blood those materials which would be injurious if retained in the system, though in the form of bile they afford important aid to the process of digestion.

239. The *kidneys* also secrete or separate from the blood certain superfluous or waste materials.

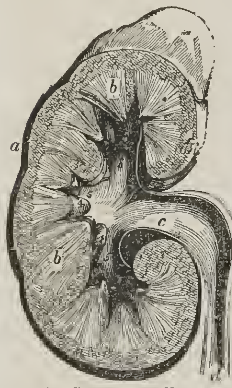


Fig. 40.—SECTION OF KIDNEY.—*a*, external or vascular portion; *b*, *b*, medullary portion; *c*, pelvis; *d*, ureter.

Fig. 41.—STRUCTURE OF THE PAROTID GLAND.

240. The external or cortical substance of each kidney is composed of an infinite number of ramifications of blood-vessels. The central or medullary part is formed of numerous straight tubes, which are collected into conical bundles, all terminating in one common basin or pelvis, as it is called. (*Fig.* 40.) As the urine is secreted in the pelvis of the kidney it is conveyed by the tubes, named ureters, into the bladder.

241. The salivary glands, including the parotid, submaxillary, and lingual, and the lachrymal glands, are all

What is the object of the secretion of bile? What is the function of the kidney? Of what is the cortical substance of the kidney composed? Of what the central or medullary portion? What do the salivary glands include?

similar in structure. They are composed of an aggregation of small lobules, the cells of which open by minute ducts, which converge and unite into larger and larger ducts, and at last into a common trunk, through which their contents are carried to the point where the peculiar fluid of each is needed. The structure of the parotid gland is represented in *fig.* 41.

242. The quantity and character of the secretion are influenced by variations in the quantity of blood, and of the peculiar materials for any secretion which it contains, and by the condition of the nervous system. An increase in the quantity of blood which passes through a gland, generally increases its secretions. Through the nerves, various emotions of the mind influence the secretions: the thoughts of food increase the flow of saliva, and grief or pain produces a flow of tears. In the case of milk, not only the quantity, but the quality, of the secretion is influenced by the state of the mind.

243. The office of *excretion* is especially performed by the lungs, the liver, the kidneys, and the skin. The lungs throw off carbon and hydrogen, in the form of carbonic acid and vapor. The liver separates the same elements from the blood, in the form of a peculiar fatty matter; the kidneys, in the form of urine; and the skin, in that of sweat. If the excretions, or either of them, be checked, they speedily accumulate in the blood, and often lead to the most deleterious results.

Of what are the salivary and lachrymal glands composed? What circumstances influence the quantity and character of the secretions? How do emotions of the mind influence the secretions? By what organs is the function of secretion performed? What substances are thrown off from the lungs?—the liver?—the kidneys?—the skin?

CHAPTER X.

THE SKIN.

244. THE *skin* is the external covering of the body, and consists of two principal layers. The *epidermis*, or scarf-skin, and the *dermis*, or true skin.

245. The *epidermis* is made up of cells in different stages of drying. Those nearest to the true skin are rounded or oval in form, and, as they approach the surface, lose by evaporation the fluid they contain, and are gradually converted into scales or scarf-skin. The outer layers of the epidermis are constantly being worn off, and new layers as constantly formed from within. Thus, each layer is gradually pushed from within, outward.

246. The *epidermis* is raised from the true skin in the formation of a blister, and portions of a considerable extent peal off after some diseases, such as scarlet fever. It is also removed with the hair, in the process of dressing the hides of animals, leaving the true skin with a smooth surface. The minute scales of which the surface of the scarf-skin is composed, are constantly cast off by ablution and friction of the skin. On the scalp, these scales are removed in the form of "*dandruff*," or scarf.

247. The pigment cells, containing the coloring matter which causes the different varieties of complexion, are deposited in the soft layers of the cuticle next to the true skin. (*Fig.* 8, PL. IX.) In Albinoes there is no coloring matter: the skin presents a uniform and pearly whiteness, and the hair is also white and colorless.

248. The epidermis is not provided with either nerves

What are the principal layers of the skin? How is the epidermis formed? What becomes of the external layers of the epidermis? How is the epidermis raised from the true skin? How are the minute scales of which the surface of epidermis is composed, cast off? How are the different varieties of complexion caused? Where are the pigment cells deposited? Why is the epidermis a hard, insensible membrane?

PLATE IX.

THE SKIN.

FIGURE 1.——*A Portion of the Epidermis of the Palm of the Hand, magnified by a simple lens*, Showing the direction of the rugæ or wrinkles, and the arrangement of the apertures of the sudoriferous glands.

FIGURE 2.——*A portion of the same, magnified one hundred diameters.*

FIGURE 3.——*A Transverse Section of the Ridges of the Epidermis of the Palm of the Hand*, Showing a side view of the apertures of the sudoriferous glands, their spiral ducts, the thickness of the epidermis in that situation, its composition of layers of cells, and its mode of connection with the true skin.

FIGURE 4.——*A Portion of the Epidermis from the back of the Hand*, Showing the disposition of the folds in that situation, the arrangement of the papillæ, the disposition of the hairs, and the apertures of the sudoriferous and sebaceous glands, magnified with a simple lens.

FIGURE 5.——*A piece of the same, magnified one hundred diameters*, Showing that each line is a furrow or groove, a provision which allows of very great extension of the epidermis.

FIGURE 6.——*A Square of Cuticle, seen upon its internal surface.*—*a*, The sulci, or depressions, which correspond with the ridges of the external surface. *b*, The ridges which correspond with the furrows of the external surface.

FIGURE 7.——*The Under Surface of the Epidermis*, Showing the pigment-cells, which contain the coloring matter of the skin.—These cells are seen to be collected principally in the furrows between the papillæ.

FIGURE 8.——*The Pigment Cells of the Negro*, Showing that his darker complexion is owing to the darkness of the color of the pigment contained in these cells.

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5.

Fig. 6.

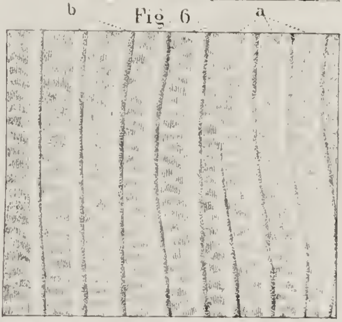


Fig. 7.

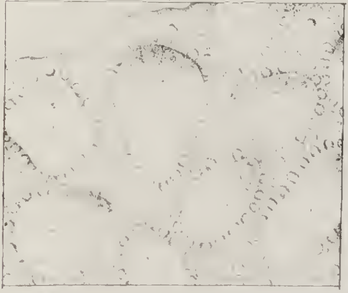


Fig. 8.

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or blood-vessels, and is therefore a hard, insensible membrane, investing the true skin, and protecting it from immediate contact with external objects. Where the friction or pressure to which it is exposed is very great, it becomes quite thick and horn-like. Thus, on the palms of the hands and the soles of the feet, it is much thicker than any where else.

249. The epidermis is marked on the surface by a network of lines, which are more numerous and larger near the joints, where they form deep wrinkles. It is perforated by numerous openings or pores, for the passage of hairs and for the perspiratory ducts. (*Figs.* 1, 2, 3, Pl. IX.)

250. The *dermis* or true skin is a firm, elastic membrane, composed of innumerable fibres, interwoven in every direction by a vast number of blood-vessels, lymphatics, and nerves.

251. Within and beneath the true skin lie the perspiratory glands, the hair follicles, and the sebaceous or oil glands. Its outer surface is studded with an infinite number of minute conical elevations, called *papillæ*. (*Fig.* 5, Pl. X.)

252. Each papilla is composed of a minute blood-vessel and a nerve, both of which form a loop, or are bent several times upon each other. The blood-vessel is usually the capillary termination of a vein in an artery. These papillæ are the seat of the sense of touch, and are so numerous over all the external parts of the body that the skin cannot be punctured by the finest needle without wounding some one of them. They are the most numerous in those parts of the body most exposed to the action of foreign agents, or where the sense of touch is most acute. They are most prominent and most densely set on the ends of

How is the epidermis affected by pressure? How is it marked on the surface? By what is the epidermis perforated? Describe the dermis or true skin. What lies beneath the true skin? Of what is each papilla composed? What is the blood-vessel? What sense is located in the papillæ? Where are they the most densely set?

the fingers and in the palms of the hands, where each raised line is composed of a double row of them.

253. The perspiratory glands are imbedded in the fatty layer beneath the skin, through which the ducts pass with a beautiful spiral coil, as represented in *fig.* 3, Pl. IX., and *fig.* 1, Pl. X., and open at the surface obliquely, so as to form a kind of valvular opening. These glands are very numerous over all parts of the body, being on an average about 2800 to every square inch of surface, or about 7,000,000 in all.

254. Fluid is constantly exhaled from the perspiratory glands, and carried off by evaporation as fast as it reaches the surface, in the form of insensible perspiration. During active exercise, or exposure to heat, it is poured off more rapidly, accumulating on the surface in drops, and is then called sensible perspiration. In warm, dry weather, when evaporation takes place rapidly, the amount of insensible perspiration may be very great. It has been estimated that from two to three pounds are daily exhaled from the skin of an adult, though the amount of insensible perspiration may be very materially increased or diminished according to the quantity of fluid taken into the system.

255. This watery exhalation serves a very important purpose in the animal economy in maintaining a uniform standard of heat, and in carrying off substances that would be highly injurious if retained in the system. The most abundant matters thus carried off are carbonic acid and water.

256. The *sebaceous* or oil glands are also imbedded in the fatty layer beneath the skin: their ducts open either

Where are the perspiratory glands located? How do the perspiratory ducts pass through the skin? How numerous are the perspiratory ducts What is constantly exhaled from the perspiratory ducts? What is sensible and what insensible perspiration? How much is estimated to be exhaled from the skin of an adult daily? How may the perspiration be increased or diminished? Of what use in the animal economy is this watery exhalation? What matters are carried off? Where are the oil glands located? Where do their ducts open?

on the surface of the skin or directly into the follicles of the hair. They are most numerous in those parts largely supplied with hair, as the scalp and face, and are thickly distributed in the nose, lips, and ears. The oily secretion of these glands serves to keep the skin supple and soft, and prevents it from drying and cracking.

257. Along the margin of the eyelids there is a row of these glands, which keep the lids smooth, and prevent the tears from trickling over their edges. Occasionally one of these glands becomes inflamed, and forms what is called a sty. In the passage of the ears, another set of these glands secretes the ear-wax.

258. The hair and nails are both regarded as appendages to the skin, and contribute to its defence. Each hair originates in a small follicle or body in the fatty substance just beneath the skin. (*Fig.* 2, PL. X.) Sebaceous glands open into these follicles, and furnish the oily material with which the hair is anointed and softened. The coloring matter of the hair is secreted by cells within the follicles, and through a deficiency of this secretion the hair becomes gray, and finally white. The shape of individual hairs is cylindrical for the smaller kinds, and oval for those which grow to any length. When left to their natural growth, the end or tip of the hair is always conical or pointed; and in most animals the portion of the hair next to the skin is smaller than the more distant portion. After the growth of the hair has reached a certain point, its nutrition ceases, and the hair falls off, to be rēplaced by another. In most animals, this occurs periodically, and is called *moulting*, or shedding of the coat. In the same manner

In what parts are the oil glands most numerous? Of what use is the oily secretion? What purpose do these glands serve on the margin of the eyelids? What are these glands called when they become inflamed? What are regarded as appendages of the skin? How does each hair originate? How are the hairs softened? How is the coloring matter secreted? What causes the hair to become gray? What is the form of each hair? What is the form of the end of hair? What part of the hair is the smallest in most animals? How do most animals shed their hair?

the antlers of deer are produced very rapidly till they have attained their growth, when they begin to harden at the base, gradually obstructing the vessels which nourish them, and then fall off, to be again rēplaced by a new and more beautiful production.

259. The nails are produced from the true skin by an organization of cells similar to the epidermis. Each nail is inserted between a fold of the skin, which is reflected backward to the root of the nail, and then passed forward beneath its under surface, to which it adheres. (*Fig.* 3, Pl. X.) In the process of growth, additions are made to its under surface and to the free edge of its root at the same time, so that growth in thickness and growth in length proceed together.

260. The use of the nails is to support and protect the ends of the fingers in grasping, and they are particularly useful in taking hold of minute objects.

261. The structure of the scales, feathers, hoofs, and horns of different animals, like that of the nails and hair, is similar to the epidermis, to which they belong. The feathers of birds are remarkable for the wonderful manner in which they combine strength and lightness with surpassing beauty. The stem or body is formed by an apparatus which may be likened to a hair follicle; but there are some additional parts, for the production of the laminæ that form the vane of the feather, which are joined to the stem during its production. These laminæ, when perfectly formed, are connected by minute barbs at their edges, which hook into one another, and thus give to the entire vane a very strong resisting surface. The substance of which feathers consist is a very bad conductor of heat; and when they are lying one upon the other, they form an admirable protection against cold and moisture.

In what manner do deer shed their antlers? How are the nails produced? Describe the insertion of the nail and the process of its growth? What is the use of the nail? What do the feathers, hoofs, and horns of animals resemble in their structure? For what are the feathers of birds remarkable? How are they formed?

PLATE I.

THE SKIN.

FIGURE 1.——*A Section of all the Layers of the Skin.*—*a*, The epidermis. *b*, *c*, The two layers of the cutis vera. *d*, A sweat-gland, surrounded by cells of fat, and sending its spiral duct upward through all the layers of the skin to the surface.

FIGURE 2.——*A Section of the Skin*, Showing the hair follicles and sebaceous glands. *a*, *a*, Sebaceous glands, opening into the hair follicle. *b*, A hair, with its follicle, *c*, surrounded by fat-cells.

FIGURE 3.——*A Section of the Thumb*, Showing the manner in which the nail is inserted between the folds of the skin.—*a*, The last bone of the thumb. *b*, The cuticle reflected upon the root of the nail. *c*, The nail. *d*, The cuticle of the point of the thumb, continuous with that at the inner surface of the nail.

FIGURE 4.——*Papillæ of the Skin*, *magnified*, containing expansions of the nerves and of the capillary blood-vessels.

FIGURE 5.——*The Spiral Arrangement of the Papillæ at the ends of the Fingers*, in which the sense of touch is especially seated.

FIGURE 6.——Sensitive hairs supplied with nerves.

Fig. 1.

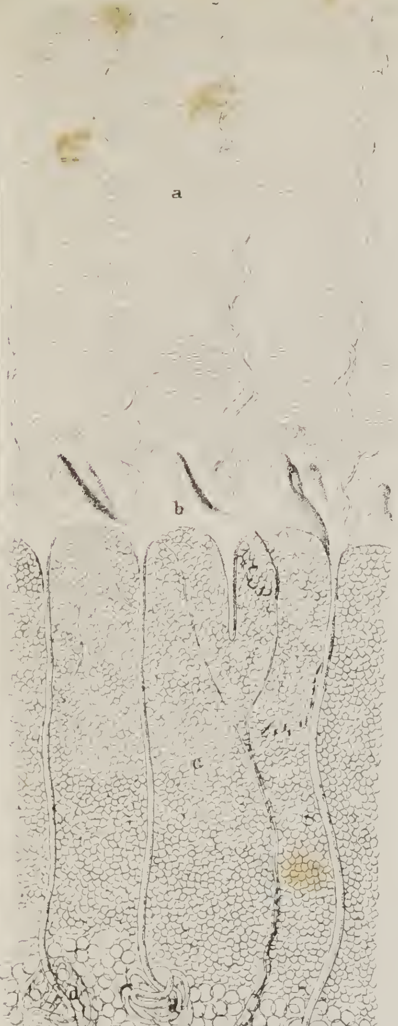


Fig. 2.

Fig. 3

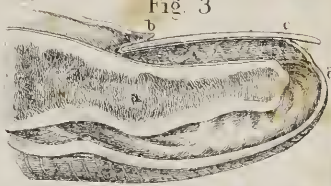


Fig. 4.

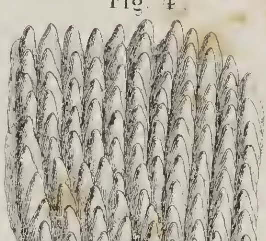


Fig. 5.

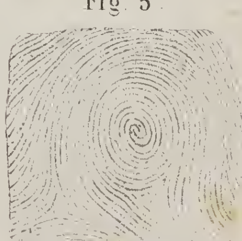
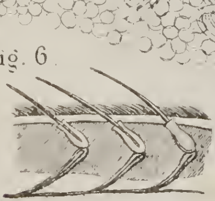


Fig. 6.



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CHAPTER XI.

THE NERVOUS SYSTEM.

262. THE *nervous system* of man and the higher animals consists of the brain, the spinal cord, the ganglia, and the nerves.

263. The brain is the centre of sensation. The spinal cord, the ganglia, and the nerves are conductors of nervous impressions.

264. The office of the nerves is to convey impressions made upon their extremities to the brain, the organ by which the mind becomes conscious of external objects, and to convey impressions from the brain to the ultimate distributions of the nerves.

265. The nerves are divided into two classes—nerves of sensation and nerves of motion. Thus, if the hand be accidentally placed in contact with a hot iron, the feeling of pain is communicated to the brain by the nerves of sensation, and the impulse to remove the hand is immediately returned from the brain by the nerves of motion. Nerves of sensation and nerves of motion have a separate origin from the nervous centre, though they are apparently the same in structure, and are usually in the same bundle of nerve fibres.

266. Nerves have no power of originating impressions. Those of sensation are stimulated by external agents, and those of motion by the will or some other force generated in the nervous centres.

267. Nervous force moves along a nerve, like the electric fluid along a wire, without the lapse of an appreciable period of time in its passage. Each nerve-fibre can carry only one kind of an impression: a nerve of motion can

Of what does the nervous system consist? Of what is the brain the centre? What is the office of the nerves? How are the nerves divided? What illustration can you give of the function of both? Have the two classes of nerves the same origin from the nervous centre? Do nerves originate impressions? How is each class of nerves stimulated? How does nervous force move along a nerve? Can a single nerve-fibre convey more than one kind of impression? What does a nerve of motion convey? What a sensitive fibre?

convey only motor impulses; a sensitive fibre can transmit only such as may produce sensation, as that of light or sound.

268. The fibres of motor nerves, which are distributed to the muscles, spread forth from their trunks into branches, which anastomose with each other, forming a kind of net-work through the muscle; but the nerves of sensation, which start from the skin, and convey impressions to the brain, originate in minute elevations or papillæ on the surface of the true skin, and in their infinite ramifications is seated the sense of touch.

269. In order that an individual may become conscious of what is passing around him, an impression must be made by external objects upon the organs of the sensitory nerves in the papillæ, and this impression must be conducted by the nervous trunk to the brain, and then it becomes a sensation. On the other hand, before the mind can cause any movement of the body to be here formed, an emotion or act of the will must produce a change at the origin of the motor nerves in the brain, and this change must be conducted along those nerves to the muscles, where it excites a contraction or muscular effort suited to the required purpose.

270. There is another kind of movement which does not seem to be excited by impressions made on the brain. They are called *reflex movements*, because impressions of this class are conducted only to certain nervous centres, and are then reflected back to the organ whence they originated.

271. Movements of this class are more particularly con-

How are the motor fibres distributed to the muscles? How do the nerves of sensation originate? What sense is seated in the ramifications of the nerves of sensation? How does an individual become conscious of what is passing around him? What takes place before any movement of the body can be effected? What are those movements called which do not seem to be excited by impressions made on the brain? Why are they called reflex movements? In what changes are the reflex movements particularly concerned?

cerned in those changes which have for their object the maintenance of organic life, such as the movements of the digestive canal, the respiratory movements, or the contraction of the eyelids and pupil, to exclude a portion of the rays of light when they are too intense for the retina.

272. The nervous centres of reflex action are the ganglia and the spinal cord. The exercise of this power by the ganglia and spinal cord is a remarkable arrangement, by which those processes that are in constant action for the maintenance of life are performed without any exercise of the will or any consciousness of the mind. It is to be feared that, if the brain was made sensitive to all the digestive and respiratory movements, the mind of many individuals would be constantly occupied with vigilant inspection of these hidden processes of nature.

273. The true nature of reflex action can be more easily comprehended by studying the comparative development of the nervous system in different groups of animals, and by noting the powers of its simplest, compared with its most perfect developments.

274. One of the simplest forms of the nervous system is found in the ascidia, (*fig.* 42,) one of the lowest of the class of mollusca. In this and similar animals, we find only a single ganglion or nervous centre. At *a* is seen the orifice by which water enters for supplying the stomach with food, and at *b* that through which it passes out again. Between these orifices is the single ganglion, *c*, which sends filaments to both orifices, and also over the surface of the envelop or mantle, *d*.

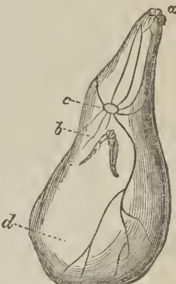

Fig. 42.—NERVOUS SYSTEM OF ASCIDIA.

What are the centres of reflex action? What particular advantage may be supposed to result from this arrangement? How may the true nature of reflex action be more easily comprehended? In what animal is one of the simplest forms of the nervous system found? Describe the nervous system of the ascidia and the phenomena of life exhibited by that animal.

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These animals are mostly fixed to one spot during their whole existence. The continual entrance and exit of the currents of water constitute the only phenomena of life which they exhibit, except when the current draws in an injurious substance. The mantle then contracts, causing a jet of water to issue from each orifice, and throw off the offending material. This little animal has no eyes or other organ of special sense. The small tentacula or feelers, at the upper orifice, are the only parts which seem to be peculiarly sensitive; and the irritation caused by the contact of a hard substance with these, or with the general surface of the body, produces an instinctive contraction of the mantle, for the purpose of getting rid of the irritating cause. This contraction can only be performed by the aid of a nervous system, which has the power of receiving impressions, and of exciting the most distant parts of the body to act in accordance with them.

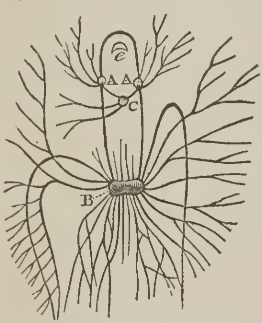


Fig. 43.—NERVOUS SYSTEM OF PECTEN.—A, A, ganglia of the head; B, respiratory ganglion; C, ganglion of the foot; *e*, œsophagus.

275. Those animals which inhabit bivalve shells exhibit the powers of respiration, sensation, and voluntary motion, and possess a corresponding development of the nervous system. In the nervous system of the *pecten* or scallop-shell, (*fig.* 43,) there is a large ganglion at B, which distributes branches to the gills and mouth, and regulates the respiratory movements. Another ganglion, C, is connected with the thick fleshy part on which the animal crawls, and which is called its foot. Near the sides of the œsophagus, *e*, are situated two other ganglia, A, A, the nerves of which are distributed to the sensitive tentacula which guard the mouth. These two *cephalic*

Describe the nervous system of the pecten.

ganglia, or ganglia of the head, evidently correspond to the brain of higher animals, being the instruments of sensation and voluntary power, and they exert a controlling direction over the movements of the animal; while the pedal and bronchial ganglia (those of the foot and of respiration) minister to the reflex actions of the organs supplied by them.

276. In animals of higher orders, the ganglia are more numerous as the variety of functions to be performed becomes greater; and in proportion as we ascend the scale, the cephalic ganglia become more and more developed, and more and more elevated above the œsophagus, until they finally meet on the central line above it, and, in the more perfect animals, take their place in the top of the head—overlooking, as it were, all the other organs.

277. The nervous system of insects whose actions are generally energetic and rapid, and in which the apparatus of motion (wings and legs) is highly developed, presents a marked difference from that of the Mollusca, which are usually inert and sluggish. It consists of a large ganglion in the head, analogous to the brain of vertebrated animals, and a chain of ganglia, one for each segment of the body, united by a double cord, as in *fig.* 44.

Fig. 44.—Nervous System of an Insect.

In the larva or caterpillar, before it is changed into the perfect insect, the nerves arising from the ganglia are chiefly distributed to the muscles of the legs, and the ganglia are only repetitions of each other, being nearly of uniform size; but in the perfect insect, the wings and legs, which con-

What is said of the ganglia in the higher orders of animals? How does the nervous system of insects compare with that of the Mollusca? Of what does the nervous system of insects consist? How are the ganglia united?

stitute the apparatus of locomotion, are confined to the thorax, and the segments of the abdomen have no legs. Accordingly, the ganglia of the thorax, in the perfect insect, are found to be very much increased in size, and sometimes concentrated in one mass, while those of the abdomen are much smaller.

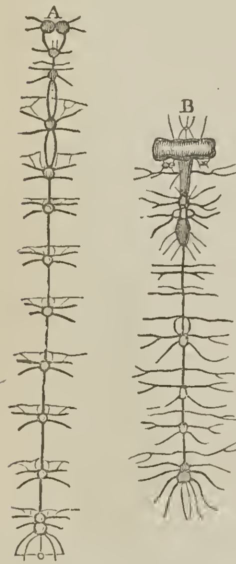


Fig. 45.—Nervous System of Sphinx-ligustri.—A, that of the caterpillar; B, that of the perfect insect.

278. This difference is shown in *fig.* 45, where A represents the nervous system of the caterpillar, from which is produced a species of sphinx or hawk-moth, and B that of the moth itself. In B, the cephalic ganglion is much larger than that of A, since it has become connected with more perfect eyes and other organs of sense. The ganglia which supply the wings and legs (those next below that of the head) are also greatly enlarged and concentrated, while the abdominal ganglia are diminished, and some of them are wanting. The whole chain is also considerably shortened, the body of the moth not being so long as that of the caterpillar.

279. The chain of ganglia in insects is found to consist of two distinct *tracts*—one is composed of nerve-fibres only, and passes from the cephalic ganglion over the surface of all the other gang lia, giving branches to the nerves which proceed from each other, while the other tract connects the ganglia themselves. Thus, each segment of the insect has a distinct nervous connection with its own ganglion, and a sympathetic connection with the others, extending to the cephalic ganglion,

How do the ganglia of the perfect insect differ from that of the larva or caterpillar? Describe Fig. 45, with the difference between A and B. Explain the arrangement of the ganglia of insects.

which seems to have a controlling influence over all the rest, and alone to possess the faculty of sensation. Hence, the motions produced by the ganglia of the trunk, when the head of the insect is removed, although they may *seem* to indicate sensation, are found to be only reflex in their nature—a certain irritation producing a certain movement without choice, and probably without consciousness, on the part of the animal.

280. Thus, if the head of a centipede be cut off while it is in motion, the body will continue to move as before; or if the body be divided as many times as it has segments, each portion will still continue to move, but all consciousness seems to be lost: for as the decapitated body comes in contact with an obstacle equal to its own height, it remains fixed against it, the legs moving as before, but without change of direction or the ability of surmounting the obstacle—being no longer subject to the will of the animal, but performing reflex movements by the influence of their own ganglia.

281. In vertebrated animals, (those which possess a backbone or spinal column) the ganglia are no longer scattered through the body, but are united into one continuous mass; and this mass, constituting the brain and spinal cord, is inclosed within the skull and vertebral column, in such a manner as to be protected from the injuries to which it would otherwise be liable. The brain in the higher vertebrata consists of a principal mass, called the *cerebrum*, which occupies all the front and upper part of the skull, and is divided into two hemispheres or halves by a membranous partition, running from back to front, and of a smaller mass, called the *cerebellum*, situated beneath the cerebrum, at the back part of the skull. At the base of the cerebrum there are two ganglia, the olfactory and

How is it shown in the case of the centipede that consciousness depends on the cephalic ganglia? How are the ganglia arranged and protected in vertebral animals? Of what parts does the brain of the higher vertebrata consist? What ganglia at the base of the cerebrum?

the optic, which belong to the nerves of smell and sight. All these parts in the human brain will be particularly described.

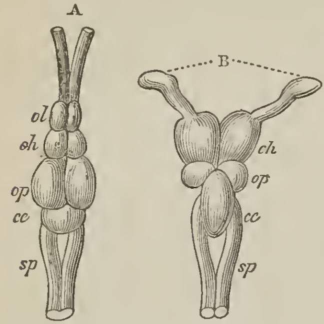


Fig. 46.—A, brain of a cod; B, brain of the shark; *ol*, olfactory ganglia; *sp*, spinal cord.

282. In the brain of a fish, (*fig.* 46,) the parts just mentioned are beginning to acquire considerable development. The cerebral hemispheres (*c*, *h*), the optic ganglia (*o*, *p*), the cerebellum (*c*, *e*), are plainly to be distinguished, and their relative sizes are in proportion to the intelligence of the animal. Thus, the ganglia which control the sense of sight are very large, since this sense is possessed in a very high degree by fishes; while the cerebral hemispheres, to which belong more especially the manifestations of will and thought, are correspondingly smaller. The cerebellum also, which, as we shall see, is connected with the powers of motion, is large, as we should expect to find it in animals possessed of the power of rapid movement, and is larger in the active and rapacious shark than in the less energetic cod. The spinal cord is large, and is divided at the top, so as to form an opening between its two halves. In man, as we shall see, this opening becomes entirely closed.

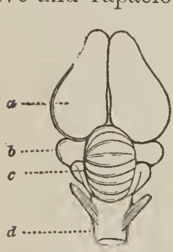


Fig. 47.—Brain of a Bird.

283. In birds, the brain has made a considerable advance towards what it finally becomes in man. The cerebral hemispheres (*a*, *fig.* 47,) are greatly increased in size, and cover in the olfactory ganglia entirely

What is said of the brain of a fish? Describe Fig. 46. What parts are large and what small in a fish? What is the comparative size of the cerebral hemispheres in birds?

and the optic ganglia (*b*) partly. The cerebellum (*c*) is also much more developed, as we should expect from the variety of movements performed by birds, but is as yet undivided into lobes. The spinal cord (*d*) is still of considerable size, and is much enlarged at the points from which originate the nerves of the wings and legs. As might be inferred from these advancements in the structure of the brain, the intelligence of birds is vastly superior to that of the animals previously considered, and they are the first in the ascending scale which are capable of education or training. Did the limits of this work permit, we might thus go on to trace the progressive development of the brain through individual species of birds and mammalia, and to show at each step a corresponding advance in intelligence as we approximate to *man*.

284. In man, the cerebral developments are greatly increased, while the spinal cord is diminished in size. The surface of the brain is not smooth, but divided by furrows into a series of convolutions, by which the surface over which the blood comes in relation with the nervous matter is greatly increased, thus adding to the activity of the organ. The two hemispheres are more closely connected with each other by fibres running across from each side. The cerebellum is divided into two hemispheres.

NERVOUS SYSTEM OF MAN.

285. The nervous system of man and of the higher animals consists of two portions—the *cerebro-spinal* and the *sympathetic* or ganglionic. The cerebro-spinal system is composed of the brain and spinal cord, with the nerves which proceed from them to the skin and muscles. It has

What is said of the cerebellum?—the spinal cord? How do birds compare in intelligence with the animals previously considered? How are the cerebral developments in man?—how the spinal cord? How is the surface of the brain in man? Of what does the nervous system of man or the higher animals consist? Of what is the cerebro-spinal system composed? What has it been called?

been called the nervous system of animal life, because it is that by which sensations are received and voluntary motions executed, and with which the mind is more immediately connected. The *sympathetic system* is connected with the nutritive processes alone, and from its influence over the organs of the thorax and abdomen, has been called the nervous system of organic life. It consists of a chain of ganglia, communicating with each other by nervous cords, extending from the head along each side of the back-bone. Nerves proceed from it to the organs of digestion and secretion, and to the heart and blood-vessels.

SPINAL CORD.

286. The spinal cord is a long irregular cylindrical column of nerve substance, surrounded by a membranous envelop, and inclosed within a long canal, formed by the vertebræ (or pieces of the back-bone). It extends from the head to the first or second vertebra of the loins, and is composed of both white and gray nervous matter. The white matter constitutes its greater portion, and is situated externally, while the gray matter occupies its central part. The spinal cord consists of two symmetrical halves, united in the middle line by a set of converging fibres, called a *commissure*, but separated anteriorly and posteriorly by a vertical fissure—the posterior fissure being deeper, but not so wide and distinct as the anterior. Each lateral half is marked by two longitudinal furrows, which divide it into three columns or tracts, called anterior, lateral, and posterior. There is a considerable enlargement of the cord in the lower part of the neck, at the part from which arises the large nerves which supply the upper extremities; and a similar enlargement is also found in the loins, at the origin of nerves which go to the lower extremities.

With what is the sympathetic system connected, and what has it been called? Of what does it consist? What is the spinal cord? How is the canal in which it is lodged formed? What is the extent of the spinal cord?—and of what does it consist? How are the two halves united? How is each half divided? What enlargements in the spinal cord?

287. The number of nerves given off by the spinal cord is thirty-one on each side: eight pairs in the region of the neck; twelve in that of the back, corresponding to the twelve pairs of ribs; five in the loins, and six in the pelvis. Each of these nerves arises by two distinct roots, one springing from the anterior column, and the other from the posterior column of the cord, as in *fig.* 48—a pair of roots on each side, corresponding to each vertebra. These roots (the posterior ones having first formed a ganglion) soon unite in a single trunk, which thus combines the properties possessed by both. The posterior set of roots consists exclusively of those fibres which convey impressions to the spinal cord and brain, and thus form the nerves of sensation; while the anterior roots consist of fibres which convey nervous influence from the brain and spinal cord to the muscles, and form the nerves of motion. Thus, if the spinal cord of an animal be laid bare, and the posterior set of roots be touched, acute pain is obviously produced; while, if the anterior roots be irritated, violent motions of the muscles supplied by the injured nerves are occasioned.

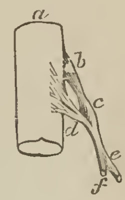


Fig 48.—PORTION OF THE SPINAL CORD, showing the origin of the nerves.—*a*, spinal cord; *b*, posterior root; *c*, ganglion; *d*, anterior root; *e*, trunk formed by both; *f*, branch.

288. The spinal cord is both a conductor of nervous impressions and a nervous centre of reflex action. When an impression is made on the extremity of a spinal nerve, it is transmitted to the spinal cord, and thence conducted to the brain, where alone it can be perceived by the mind. In like manner, the stimulus of the will which originates in the brain is conducted along the cord, and thence to the

How many nerves are given off by the spinal cord? How many pairs are given off in the neck—back—loins—pelvis? How does each nerve arise from the spinal cord? Of what fibres do the posterior roots consist?—the anterior? What would be the effect of irritating the anterior or the posterior, if the spinal cord of an animal was laid bare? What two functions does the spinal cord perform? Explain how it acts as a conductor of nervous impressions.

nerves. In case the spinal cord is lacerated or torn asunder at any point, as sometimes happens in fracture of the spine, this communication to and fro between the brain and the nerves is interrupted, so that the will has no longer any control over the parts below the injury, nor is the mind conscious of any injury that may be inflicted on them. Thus, if the cord be severed in the loins, sensation and the power of voluntary motion in the lower extremities will be lost, while they will be in full exercise in the upper extremities.

289. The spinal cord is also a nervous centre of reflex action. During sleep, when the brain is inactive, respiration and all those movements necessary to life go on as usual: liquid poured into the mouth is swallowed—the body changes its position. An animal whose cerebrum has been removed, does the same things. A pigeon, for instance, has been kept alive for several months in that condition; running when pushed, flying when thrown into the air, drinking when its beak was plunged into water, and swallowing food when placed in its mouth, but at all other times appearing in a profound sleep.

290. From such facts, it is evident that the spinal cord must possess a great degree of independent power; but it differs from that of the brain in this, that it is exerted without the concurrence of the judgment and the will; and the movements produced by it are rather like those of an automaton, set in motion by pulling certain wires or touching certain springs. Thus, the motions of a decapitated animal are never spontaneous, but always excited by a stimulus of some kind.

What are the effects of lacerating or dividing the cord? Explain how the spinal cord is a nervous centre of reflex actions? Does the spinal cord possess any degree of independent power? How does it differ from that of the brain?

MEDULLA OBLONGATA.

291. At its upper part the spinal cord becomes greatly enlarged, and forms a bulb-shaped body, called the medulla oblongata, which is inclosed within the skull, and through which the connection between the spinal cord and the brain is preserved. Its columns are continuous with those of the spinal cord, but are more prominent, and it contains a larger quantity of gray matter. It is connected with the nerves of respiration, mastication, and deglutition, and may be considered as the common centre of the cerebro-spinal system.

292. The medulla oblongata differs from the rest of the spinal cord in its functions mainly in the importance and extent of the actions governed by it. Like the cord, it is a conductor of nervous impressions; but it has a wider extent of function, since all impressions which pass to and from the brain and spinal cord must be transmitted through it. Motor impressions are transmitted through its anterior columns, and sensitive impressions through its posterior columns. Thus, if one of its anterior columns be divided, the animal will lose the power of motion in one half of the body, while its sensation will remain unimpaired.

293. The functions of the medulla oblongata, as a nervous centre, are more immediately important to the maintenance of life than that of any other part of the system. The nervous force necessary for deglutition and respiration is generated in this organ. It has been proved by repeated experiments that the entire brain may be cut away, in successive portions, and life yet continue for a considerable period, and the respiratory movements be

Where is the medulla oblongata? How is it formed? What is said of its columns? With what functions are its nerves connected? How does the medulla oblongata differ from the rest of the spinal cord? Of what importance to the maintenance of life are the functions of the medulla oblongata? By what experiments has it been proved that life can be maintained so long as this portion remains uninjured?

uninterrupted. Life may also continue when the spinal cord is in like manner cut away from below upward as high as the phrenic nerve, which commences near the throat. In some of the amphibia, (tortoises, frogs, &c.,) the brain and spinal cord have both been thus removed, and still respiration and life continued so long as the medulla oblongata was untouched. But a very slight wound at its central portion will produce suffocation and sudden death.

294. The power of reflex action is more apparent in this than in any other portion of the nervous centres. By this power, the respiratory movements are carried on. Thus, the application of stimuli to many parts of the body, the nerves of which transmit impressions to the medulla, will cause respiratory movements by reflection through the nerves which proceed from the medulla to the muscles concerned in respiration. This accounts for the "*catching for breath*" produced by dashing cold water in the face. Convulsive movements are also produced through the agency of this part of the cord. In those convulsions which result from the teething of children, in lock-jaw, and other like diseases, death usually ensues from suffocation—the muscles of respiration becoming so fixed that the air cannot be breathed.

THE BRAIN.

295. The human brain consists of two principal portions —the *cerebrum* or large brain, and the *cerebellum* or small brain—protected by their membranes, and inclosed within the cranium or skull. The cerebrum, which constitutes nearly seven-eighths of the whole mass, occupies all the upper and anterior portions of the cranium, and is divided

What has been said of the power of reflex action in this portion? What effects are produced on the respiratory movements by stimuli applied to other portions of the body? How are convulsions often produced? What is usually the immediate cause of death in such cases? Of how many portions does the brain consist, and what are they called? What portion of the cranium is occupied by the cerebrum?

into two hemispheres or lateral halves. These are connected by transverse bands or commissures of nervous matter, and each hemisphere has three prominent masses or lobes—one at the forehead, one at the temples, and one at the back of the head. Its surface is intersected by deep fissures and eminences, which produce those winding inequalities called convolutions.

296. The nervous tissue of the cerebrum is composed of white and gray substances, disposed in a peculiar manner: a layer of the gray substance occupies the surface, and follows all the irregularities of the convolutions, while the white substance is placed in the central parts. Thus, each convolution consists of a layer of gray substance at the outside and of white substance within. The manner in which the two substances are thus arranged to form the convolutions, may be rudely illustrated by taking two pieces of cloth, laying one upon the other, and collecting them up into folds in a globular shape. By such arrangement, the surface over which the blood comes in contact with the nervous matter is greatly increased, and it is interesting to know that in man the convolutions are more numerous and extensive, and the depressions between them deeper, than in any other animal. The brain is most abundantly supplied with blood—the amount sent to it having been estimated as high as one-fifth of that contained in the whole body, though one-tenth would be probably nearer the truth.

297. Towards the base and centre of the cerebrum, the surface is inflected inward, so as to form an intricate internal cavity, several compartments of which are called ven

How is the cerebrum divided? How are the two halves connected together? What is the external appearance of each hemisphere? Of what is the nervous tissue of the cerebrum composed? How are the white and gray substances disposed? How may the manner in which the two substances are disposed be illustrated? What is the effect of this arrangement? What proportion of the whole amount of blood has been estimated to be sent to the brain? What are the internal cavities called?

tricles. They communicate with each other, and serve still further to increase the cerebral surfaces. It is in these ventricles that collections of serous fluid take place, in cases of what is called "dropsy of the brain," or water in the head.

298. The cerebellum is situated at the back of the head, below the cerebrum. It is divided into two lateral lobes, and, instead of waving convolutions, its surface presents a number of plaits with furrows between them. It is composed, like the cerebrum, of gray and white matter, and the white matter presents, on a vertical section of one of the lobes, a tree-like appearance, called *arbor vitæ* (tree of life).

299. The membranes which surround and protect the brain are three in number, and are called the *dura mater*, the *arachnoid*, and the *pia mater*. These membranes are also prolonged downwards, so as to form a tubular sheath to the spinal cord. The *dura mater* (hard mother) was so called by the old anatomists, because they supposed it to be the origin or mother of all the hard, firm membranes of the body, and the *pia mater* (tender mother) was also thus named by them, as being the origin of the soft membranes.

300. The dura mater is a strong, dense, fibrous membrane, which forms the external envelop of the brain, and is in contact with the bones of the skull, to which it strongly adheres. It is separated into two layers, the internal of which is doubled on itself, so as to form two remarkable processes: the one, from its resemblance in shape to a sickle, is called *falx cerebri*, and is interposed between the two hemispheres of the brain, so that when the head

How do they communicate with each other? Where is the cerebellum situated?—how is it divided? Of what two substances is it composed? What is the appearance of the matter when divided vertically? How is the brain protected? What was the origin of the name applied to the dura mater and pia mater? Describe the dura mater. What is that portion of the dura mater called which divides the two hemispheres?

rests on one side, the uppermost hemisphere is prevented from pressing upon the lower. The other process is called *tentorium cerebelli*, and is extended over the cerebellum, so as to prevent the pressure of the cerebrum upon the latter when the head is in an erect position. There is also a smaller process, called *falx cerebelli*, which separates the two hemispheres of the cerebellum.

301. The *arachnoid* (spider's web) membrane, so called from its extreme thinness, lies beneath the dura mater, and is spread over the entire surface of the brain. It corresponds in its use to the serous membranes of the heart and other organs, and serves to keep the opposite surfaces of the dura mater and the pia mater, between which it lies, moist and smooth.

302. The pia mater is a loose transparent web, in which a multitude of blood-vessels cross each other in every possible direction. Minute branches of these vessels, in immense numbers, penetrate the brain, to which they afford nutriment, at the same time that they serve as a means of attachment between the brain and membrane. The pia mater follows all the convolutions, entering all the cavities of the brain, and is also prolonged over the spinal cord and the nerves, constituting one of the most important membranes of the body.

303. Twelve pairs of nerves are given off from the brain, and are named as follows: 1st pair, Olfactory nerves; 2d, Optic Nerves; 3d, Motores Oculorum; 4th, Pathcticus 5th, Trifacial nerves; 6th, Abducentes; 7th, Portio dura, or facial nerves; 8th, Portio Mollis, or auditory nerves, 9th, Glosso-pharyngeal nerve; 10th, Pneumogastric nerve; 11th, Hypo-glossal nerve; 12th, Spinal accessory nerve.

304. The first pair is distributed to the inner membrane of the nose, and transmits to the brain the impression pro-

What other processes are there? Describe the arachnoid membrane. Describe the pia mater. How many pairs of nerves are given off from the brain? What are they called? Where is the first pair distributed, and what is its office?—the second?

duced by odors. The second pair is distributed to the retina of the eyes, and in like manner conveys the impression of sight. The third, fourth, and sixth pairs are nerves of motion only, and are distributed to the muscles which move the eyes. The fifth pair is for the most part a nerve of sensation only; it is divided into three branches —the first of which, called the ophthalmic nerve, passes into the orbit or cavity in which the eye is lodged, and is then distributed to the forehead and temples. The second branch, or superior maxillary, supplies the cheeks, nose, and upper-lip with sensitive filaments. The third, or inferior maxillary, which, like the spinal nerves, has also a motor root, imparts the power of moving to the masticating muscles, and gives sensibility to the parts about the mouth.

305. The seventh pair is the general motor nerve of the muscles of the face; the eighth pair is the nerve of hearing, and is distributed to the internal ear; the ninth pair supplies the back of the mouth and pharynx, and is concerned in the act of swallowing; the tenth pair originates from the medulla oblongata, and supplies the lungs and air passages, as also the heart and stomach; the eleventh pair gives motion to the tongue; and the twelfth pair is concerned in respiration. All these nerves are supposed to contain two sets of filaments—one communicating with the cerebral hemispheres, and the other with the spinal cord. PLATE XI., *fig.* 4, represents a section of the brain, showing the arrangements of these nerves. That of the nerves proceeding from the spinal cord is seen in PLATE XI., *fig.* 1.

What are the third, fourth, and sixth pairs? What is the fifth pair? How is it divided? Where is each branch of the fifth distributed? What is the seventh pair?—the eighth? What is the origin of the ninth pair? What organs does it supply? To what parts do the eleventh and twelfth give motion? What two sets of filaments are all these nerves supposed to contain?

PLATE XI.

THE BRAIN AND SPINAL CORD.

FIGURE 1.——*Anterior View of the Brain and Spinal Cord, isolated from the Skeleton.*—*a*, *b*, Right and left hemispheres of the brain, the left hemisphere covered by the arachnoid and pia-mater; the right hemisphere naked, displaying the convolutions. *c*, *d*, Right and left lobes of the cerebellum. *e*, The medulla oblongata. *f*, *f*, The spinal cord, covered by the pia-mater on the right side, and showing the origins of the spinal nerves on the left. At *f*, *f*, are seen the two enlargements of the cord, in the neck and the loins. *g* to *g*, The eight cervical pairs of nerves; *h* to *h*, The twelve dorsal pairs; *i* to *i*, The five lumbar pairs; *k*, *k*, The six sacral pairs. *l*, Lateral column of the cord. *m*, Posterior column.

FIGURE 2.——*A Section of the Brain and Spinal Cord, inclosed in the Skull and Vertebral Column.*—*a*, The cerebrum. *b*, cerebellum. *c*, *c*, The spinal cord.—The vertebræ are cut through, so as to display a lateral view of the cord.

FIGURE 3.——*The Cerebellum.*—*A*, Anterior view. *B*, Posterior view.

FIGURE 4.——*A Vertical Section of the Brain, showing the Origins of its Nerves.*—*a*, *a*, The cerebrum, with its convolutions. *b*, The cerebellum, displaying the arbor-vitæ upon its section. *c*, The medulla oblongata. *d*, The corpus callosum, a band of fibres which connects the two hemispheres of the brain. *e*, The eye. *f*, The first pair of nerves. *g*, The second pair. *h*, The third pair. *i*, The fourth pair. *j*, The fifth pair. *k*, The sixth pair. *l*, The seventh pair. *m*, The eighth pair. *n*, The ninth pair. *o*, The tenth pair. *p*, The eleventh pair. *q*, The twelfth pair. *r*, Spinal nerves.

FIGURE 5.——*A Horizontal Section of the Brain, showing its Interior.*—*a*, *a*, The cineritious or gray substance at the outside of the brain, following the convolutions. *b*, *b*, The white or medullary substance at the inside of the brain. *c*, *c*, The lateral and middle ventricles.

Fig. 1.

Fig. 2.

Fig. 3.

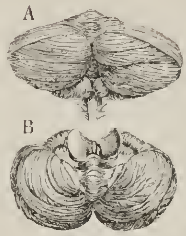


Fig. 4.

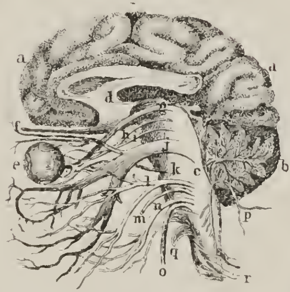
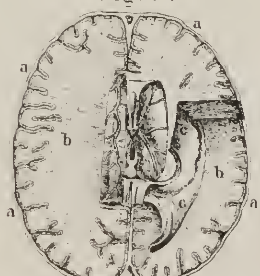


Fig. 5.



Hartford Conn.

FUNCTIONS OF THE CEREBELLUM.

306. Much discussion has taken place in regard to the functions of the cerebellum. It seems to be now agreed, however, by the most intelligent physiologists, that it is the organ which is more especially connected with motion. Numerous experiments have been made on living animals, all of which go to show that, after the removal of the cerebellum, the power of executing those movements necessary to locomotion is lost. The faculties of volition and sensation remain; but the power to walk, fly, or even stand, is uniformly lost, from the inability to combine the action of the muscles in groups.

307. From facts of this character, it seems to be most probable that the function of the cerebellum is to harmonize and regulate the actions of the voluntary muscles. In accordance with this theory, we find that those animals which possess variety of motions, or muscular action in the highest degree, are endowed with a cerebellum correspondingly large.

308. In the animals of the cat tribe, which use their limbs for seizing their prey, and which are capable of great muscular exertion, the cerebellum is larger than in those whose limbs are subservient to locomotion only. In birds, the variety of whose movements is still greater, it is larger than in most of the mammalia. It acquires its highest development in man, as might be expected, from the muscular combinations necessary to maintain the erect position, and to perform the intricate and varied movements of the human hand.

What is said in regard to the functions of the cerebellum? How is it regarded by the most intelligent physiologists? What do experiments on living animals show in regard to the formations of the cerebellum? What is most probably the function then of the cerebellum? What is said in regard to the development of the cerebellum in the cat tribe and in birds? In what class does the cerebellum acquire its highest development?

309. The influence of each half of the cerebellum is directed to muscles on the opposite sides of the body; and it would appear that, for the right ordering of movements, the action of its two halves must be always mutually balanced and adjusted.

FUNCTIONS OF THE CEREBRUM.

310. The cerebrum is the organ through which the phenomena of thought and intelligence are manifested. By its means, we reason upon the ideas excited by sensations, we judge and decide upon our course of action, and put that decision into practice by issuing a mandate which is conveyed by the nervous trunks to the muscles.

311. It is a common, but erroneous idea, that reason is peculiar to man, and that the actions of the lower classes of animals are due to instinct alone. There can be no doubt that reasoning processes, exactly resembling those of man, are performed by many animals: such, for instance, as the dog, the horse, and the elephant. We must admit that an animal reasons when it profits by experience, and obviously adapts its actions to the end it desires to gain, especially when it departs from its natural instincts to do this. The presence of intelligence is also perceived in the differences of character found in various individuals of the same species. Thus, some dogs are stupid, others sagacious, some ill-tempered, others good-tempered; just as there are stupid men and intelligent men, ill-tempered men and good-tempered men. But the actions of insects seem to be wholly instinctive, so that we observe no difference of temper or capacity in them.

312. Birds, however, which resemble insects in many

What is said in regard to the influence of each half of the cerebellum? What is the function of the cerebrum? Is reason peculiar to man? When may an animal be said to reason? How may we discover the presence of intelligence in animals? What example is given of different degrees of intelligence in an animal? What seems to be the nature of the actions of insects? What is said in regard to birds?

of their instinctive tendencies, exhibit a remarkable distinction in their actions. In escaping from danger, in obtaining food, and in constructing their habitations, the actions of birds, like those of insects, are instinctive. But in adapting their operations to peculiar circumstances, birds display a variety and fertility of resource not to be found in insects; and birds also learn by experience, and may be educated, while insects observe perfect uniformity in all their actions.

313. The relative amount of intelligence in different animals bears a pretty constant proportion to the size and development of the cerebral hemispheres. Size alone, however, does not produce all the difference. In ascending from the lower to the higher animals, a marked advance in the complexion of the brain is observed: the convolutions become more and more prominent, giving a proportionably increased surface for the entrance of the blood-vessels, and an equally increased amount of the gray matter which seems to be the real centre of all the operations of the organ. Still, the size of the cerebrum, compared with that of the spinal cord and the ganglia at its top, usually affords a tolerably correct measure of the intelligence of the animal. The same rule holds good in comparing different men, if due allowance be made for the comparative activity of their general functions, or, in other words, for their differences in temperament.

314. Thus, two men whose brain is of the same size may differ widely in mental vigor, because the general system of one performs its functions more actively and energetically than that of the other. For the same reason, a man

In what actions do birds seem to be governed by instinct, and in what by intelligence? How does the amount of intelligence in different animals compare with the development of the cerebral hemispheres Is all the difference produced by size alone? What other circumstances are to be taken into the account? What is said of the size of the cerebellum, compared with that of the spinal cord? How does this rule hold in regard to different men? Why may two men whose brains are of the same size differ widely in mental vigor? Under what circumstances will a large brain surpass a small one in power?

of small brain, but whose general habit is active, may have a more powerful intellect than another of much larger brain, but whose system is sluggish and inert. But of two men alike in temperament, and having the same general configuration of head, it cannot be doubted that the one with the larger brain will surpass the other. It is a striking fact, that almost all those persons who have been eminent for their acquirements, or for the influence of their talents over their fellow-men, have had large brains. This was the case, for example, with Newton, Byron, Cuvier, Cromwell, and Napoleon. The average weight of the brain is about three pounds two ounces. That of Cuvier weighed four pounds eleven and a half ounces, and those of Byron and Cromwell are said (though the fact is doubtful) to have weighed nearly six pounds. In idiots, on the contrary, the brain is usually very small—in some instances weighing only one and a half pounds.

315. The size of the brain may be pretty correctly estimated by the facial angle. This angle is obtained by drawing a horizontal line (*c*, *d*, *figs.* 49 and 50) from the

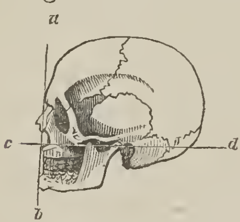


Fig. 49.—Skull of European.

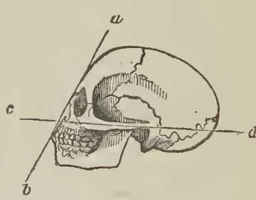


Fig. 50.—Skull of Negro.

entrance of the ear to the floor of the cavity of the nose, and a second line (*a*, *b*) from the most prominent part of the forehead to the front of the upper jaw, so as to intersect the other. This line will evidently be more inclined to the former, and the angle formed by the two will be

What has been said in regard to the size of the brain in men who have been distinguished for their talents? What examples are given of large brains? How is the brain in idiots? How may the size of the brain be estimated?

PLATE XII.

THE NERVES.

FIGURE 1.——*Posterior View of the Principal Nerves.*—The general arrangement of the nervous centres and the distribution of the nervous trunks are shown in this figure.—The spinal column is laid open, so as to display the cord, with the nerves which pass from it. The muscles of the left side and limbs are dissected, to show the course of the principal nerves.

a, The hemispheres of the cerebrum. *b*, The lobes of the cerebellum. *c*, The spinal cord. *d*, The facial nerve, the principal motor nerve of the face. *e*, The brachial plexus, a net-work of nerves, originating by several roots from the spinal cord, and going to supply the arm.—From this plexus proceed—*f*, the scapular nerve; *g*, the median nerve; *h*, the ulnar nerve; *i*, the musculo-spiral nerve; *j*, the intercosto-humeral (nerve of Wrisberg). From the spinal cord proceed—the intercostal nerves, *k*, *k*, running between the ribs; the nerves forming the lumbar plexus, *l*, from which the front of the leg is supplied; those forming the sacral plexus, *m*, which supplies the back of the leg. The chief branch of the sacral plexus is the great sciatic nerve, *n*, which divides into the tibial nerve, *o*, the peroneal or fibular nerve, *p*, and many other branches. The nerves seen on the right side of the figure, are the ramifications of the sub-cutaneous nerves, branching beneath the skin, in which they are finally lost. Some of the superficial veins are also represented.

Fig. 1

Harr…

more acute in proportion as the face is more projecting and the forehead more retreating; while it will be nearer a right angle, if the forehead be prominent and the muzzle projecting but little. Hence, the facial angle will indicate the proportion which the brain bears to the face.

316. This angle is more open in man than in any other animal, and it varies greatly in the various races of men. The difference between the facial angle of the European and American head, and that of the negro, is seen in *figs.* 49 and 50. In the one, it is about eighty degrees, and in the other about seventy. In monkeys, it varies from about sixty-five to thirty degrees, and as we descend still lower, it becomes still more acute.

CONNECTION OF THE MIND WITH THE BODY.

317. The brain, as appears from what has already been said, is the connecting link between the mind and the body. All the organs of the body may be said to be the agents of the mind, inasmuch as the mind manifests itself through them all. Thus, the hand, the eye, the muscles which control the features, are all made to express, more or less forcibly, the varied emotions of the mind. The mind, too, controls, to a certain extent, the operations of the various functions of the body, to which it gives a shape and form in correspondence with itself.

318. In this view, we may regard the entire body as an assemblage of organs for the manifestation of the mind. But the influence of the mind upon the body is reciprocated by that of the body upon the mind. If the body can be made to suffer from the condition of the mind, the

In what class is the facial angle more open than in all others? How does it vary in different races? What is the facial angle of an European or an American—of a negro—of a monkey? What may we regard as the connecting link between the mind and the body? How may we regard all the organs of the body? What parts are made to express the emotion of the mind? What control does the mind exert over the body? What then may we regard the body? How is the influence of the mind upon the body reciprocated?

mind itself is not less affected by the condition of the body. A single illustration will suffice to show this fact: Melancholy, or depression of spirits from any cause whatever, will often produce disease and derangement of the liver; and, on the other hand, a derangement of the liver will almost always insure melancholy, though no other cause exists.

319. But the intellect is not limited in its influence to the organic and animal functions: it also stamps itself upon every lineament and feature of the man. Thus, as we ascend in the scale of being, intelligence becomes more highly developed, and is marked by a more perfect organization of the brain and nervous system. The nervous power in man is at its highest point, as is shown by the very liability to disease or derangement of the vital functions, arising from the sympathy between the physical and intellectual powers. The mere animal has no desires to gratify but those of appetite. These satiated, he has no anxiety for the future—no repinings for the past; he is not wasted by care, nor harassed by toil and disappointment. Man, on the contrary, is the constant subject of exciting and depressing influences—of functional and organic derangements, growing out of his complex nature. Ever restless, never satisfied, he is constantly on the rack of physical and mental torture. He consequently obtains the highest perfection and excellence when he obeys most perfectly the laws of his nature, and retains the physical and the intellectual in the most complete harmony of development.

320. Hence, in the education of the young, the powers of the body and mind should be cultivated together. The

What illustration is given to show this fact? Upon what does the intellect stamp itself? As we ascend the scale of being, how is intelligence marked? How is it shown that the nervous power is at its highest point in man? What is said in regard to the cares and anxieties of man, compared with other animals? When does man obtain the highest perfection? What should be observed in the education of the young?

mind should not be excited to such a degree as to overtask the brain, nor so neglected as to leave the latter without a proper degree of exercise. One extreme wastes the vital energies while yet immature; the other degrades heaven-born powers to a level with the brute. The injudicious course, so often pursued, of stimulating the intellect of what is called a "precocious child," too often results in misery in the sufferer itself, and in disappointment to its unwise friends. Such children rarely fulfill the promise of their earliest years, and the anxious parent usually sees the brilliancy of their youth fade into dullness or disease in after-life.

321. During the first six or eight years, the most important object in the education of the young is to develop the physical powers, and secure vigor and strength to the body. If there is a tendency to an early development of the intellectual powers, special care should be taken to restrain the exercise of the mind, till the physical powers shall become strong and healthy, rather than fan the flame already kindled till it consumes the citadel of life.

322. In the subsequent development of the intellectual faculties, gradual and uniform progress is greatly to be preferred to rapid strides in knowledge. They who at first rush furiously up the rugged path of science, are sure very soon to tire or fall sick by the way. Nor should the mind ever be confined too long on any particular study; a suitable variety not only refreshes the mind, but affords a more harmonious development of all the powers. The young especially require variety: their minds are constantly on the alert for something new—something to see,

What is said in regard to neglecting or exciting the mind What is the result of either extreme? What is often the result of injudiciously stimulating the intellect of precocious children? What is the most important object during the first six or eight years? What should be done if there is a tendency to an early development of the intellectual powers? What is to be preferred in the subsequent development of the intellectual faculties? What is said in regard to variety of study?

handle, and taste—or for some new thought or truth. Continued application, for a great length of time, is wholly incompatible with their natural impulses, and fatigue very soon ensues when it is attempted; for the mind seeks variety with the same irresistible tendency that the body seeks change of position.

323. In more mature years, the mind should be trained to earnest and patient thought, but not with unremitting toil. The best thinkers are those who possess the power of exerting their brains with the most energy for a limited period of time, and who then take liberal relaxation. The brain thereby exercises the power of prompt, energetic action; and when it acts, it is to some purpose. Those who keep the brain constantly at work, either become dull and lazy thinkers, or are prematurely worn out. The men who have done the most for the world and for the race, are men of vigorous thought and liberal exercise —men who take care of the body while they work the mind. The reason why genius so often finds an early grave, is because the intense exitement it creates in the brain soon exhausts the physical energies.

How should the mind be trained in more mature years? Who are usually the best thinkers? What is the effect of keeping the brain constantly at work? Who are the men who have done the most for the world? Why does genius so often find an early grave?

CHAPTER XII.

THE SENSES.

324. THERE are five senses: *touch*, *taste*, *smell*, *hearing*, and *sight*. The office of the senses is to make us acquainted with the material world around us, and the states of our own bodies. Our knowledge of the properties of matter, and our ideas of form, taste, odor, and sound, are all obtained from impressions made on the mind through the senses.

SENSE OF TOUCH.

325. The sense of *touch* is the most universally diffused of all the senses, existing in greater or less perfection in all animals. In some, as in man, nearly the whole exterior of the body is endowed with it; but in others it is limited to certain parts in which it is specially seated. In insects, the surface of the body is covered with an insensible shell, and the organs of touch are the antennæ, or *feelers*. These are prolongations from the portion of the head near the mouth; they are often of very great length, as in *fig.* 51, usually containing a great number of points, and are very flexible, so that they can be turned toward any object the insect may wish to examine. In walking, the antennæ are used almost incessantly in touching the surfaces over which they pass, and they seem

Fig. 51.—CAPRICORN BEETLE.—*a*, *a*, antennæ.

How many senses are there? What is the office of the senses? How do we obtain our ideas of form, taste, odor, and sound? Which of the senses is the most universally diffused? What is the extent in man? How is it limited in other animals? What are the organs of touch in insects?

to be the medium of some kind of correspondence with each other; for ants or bees are seldom seen to meet without reconnoitering one another with their antennæ.

326. In fishes, the body is so covered by scales as to be nearly insensible. In those animals which are covered with hair, the sense of touch is most perfectly developed in those parts which are most uncovered, and are brought in contact with the substances on which they feed. The sensibility of the lips of the horse, for example, is very great. The carnivorous animals are usually provided with long hairs or "*whiskers*," each of which at its root is in contact with a filament of nerve. (*Fig.* 6, Pl. X.)

327. In most of the mammalia, the lips and tongue are employed as the chief organs of touch. In the elephant, this sense is possessed very acutely by the little finger-like projection at the end of its trunk; and in the bat, it seems to be diffused over the whole membrane of which the wings are formed.

328. In man, the true skin is studded with minute papillæ, and each papilla is provided with a termination or a loop of a sensitory nerve. The whole external surface of the body is thus more or less highly endowed with this faculty, according as the papillæ are more or less numerous in any particular part. In the hand, and especially at the extremities of the fingers, these papillæ are extremely numerous, and the sense of touch is here most acute. (*Figs.* 4 and 5, Pl. X.) The hand is capable of a great variety of movements, as well as a high degree of improvement by education. In the blind, who learn to read with

What is the condition of the body in fishes? Where is the sense of touch most perfectly developed in animals which are covered with hair? What is said of the lips of the horse and the whiskers of carnivorous animals? What are the chief organs of touch in most of the mammalia? In what parts is it possessed very acutely by the elephant and the bat? With what is the true skin in man studded? With what is each papilla provided? Where are the papilla the most numerous, and the sense of touch the most acute? What is said of the improvement of the hand by education? How do the blind learn to read?

facility by simply touching the raised letters, this sense acquires most wonderful acuteness and precision.

329. In animals, the sense of touch is almost wholly confined to the surfaces of the body, while the deeper parts are comparatively free from it, though not insensible to pain from injury or disease. In case of an ordinary cut or bruise, or a surgical operation, the most acute suffering arises from the violence inflicted on the sensitive nerves near the surface. Thus, a wound that is only "skin deep," will sometimes cause quite as much immediate pain as a more serious injury to the deep-seated parts. The sense of *Touch* may therefore be regarded as an ever-watchful sentinel, placed on the exterior of our bodies to guard with untiring vigilance the delicate textures within.

SENSE OF TASTE.

330. Taste is that sense by which we judge of certain properties of matter—as sweet, sour, bitter, &c. Its chief purpose is to direct animals in the choice of food. Like the sense of touch, it is not excited except by the direct contact of particular substances; and only those substances which are soluble in water, or in the fluids of the mouth, make any impression on this organ. Substances that are not soluble, are said to be either insipid or tasteless.

331. The sense of taste, in the higher animals, is con fined principally to the mucous membrane of the tongue, which is very thickly set, especially on its upper surface, with papillæ. The papillæ of the tongue have some resemblance in structure to those of the skin, though they are far more highly organized. (*Fig.* 1, Pl. XIII.)

332. The papillæ of the tongue are of various forms

To what parts is the sense of touch almost wholly confined in all animals? Where is the pain the most acute in cases of injury? What may we regard the sense of touch? What is taste? What is its chief purpose? How is the sense of taste excited? What is said of substances that are not soluble? To what parts is the sense of taste chiefly confined? What is said of the papillæ of the tongue?—of their form and size?

and sizes: some are conical; others are enlarged and flattened at the top; some are elevated above the surface of the tongue; and others are imbedded beneath it. The fungiform papillæ, which are supposed to be the special instruments of the sense of taste, are composed of numerous loops of capillary vessels, with a bundle of nerve-fibres, as represented in *fig.* 5, Pl. XIII.

333. The tongue itself is made up of muscular substance, which accomplishes the various movements required in the act of mastication, and in the production of sounds. It possesses nearly the same structure in the other mammalia as in man. In birds, it is usually cartilaginous or bony in its texture, and destitute of nervous papillæ, so that their sense of taste cannot be very acute. Several of them use their tongues for other purposes. The woodpecker, for instance, (*fig.* 6, Pl. XIII.) whose tongue is sharp and forked, transfixes insects with it; and the parrot uses it to keep steady the nut or seed which is being crushed between its mandibles. In some reptiles, the tongue is large and fleshy; in others, as the serpent tribe, it is sharp and forked, and possessed of very great quickness of motion. In the frog and chameleon, it serves as an organ of prehension, and is darted out with great rapidity to catch the insects on which these animals feed. The tongue of the fish is generally in a more rudimentary state; it is fixed in the throat, and often covered with teeth. The tongue of the bee forms a little tube, through which it draws up the juices of flowers.

334. Most of the lower animals are instinctively directed in the choice of their food by the sense of taste, rejecting what is pernicious, and selecting whatever is adapted to

Describe the fungiform papillæ? Of what is the tongue itself made up? What is the structure of the tongue in birds? For what other purposes is the tongue of some birds used? What is said of the tongue in reptiles?—in serpents?—in the frog, and the chameleon? What of the tongue of the fish and the bee? How are most of the lower animals directed in the choice of their food?

PLATE XIII.

ORGANS OF SENSE.

FIGURE 1.——*The Dorsum, or Upper Surface of the Tongue.*—*a*, The epiglottis. *b*, The root of the tongue. *c*, *c*, Mucous-glands, covering the root of the tongue. *d*, *d*, *d*, The large papillæ, arranged in two oblique lines, meeting at the middle of the root of the tongue. Spreading over the rest of the surface are seen the small papillæ, in great numbers and of different shapes and sizes.

FIGURE 2.——*The Inferior Surface of the Tongue.*—This figure represents the lower side of the tongue laid open, so as to show the distribution of the nerves. *a*, The hyoid-bone, to which the base of the tongue is attached. *b*, *b*, The stylo-glossus muscles, reaching from the tongue to the styloid processes of the temporal-bone, *c*, *c*. Their action is to draw the tongue backward. *d*, The hypo-glossal nerve.—Minute filaments of these nerves are spread throughout the tongue and in its papillæ.

FIGURE 3.——ORGAN OF HEARING: *Vertical Section of the Organ of Hearing.*—*a*, *b*, *c*, The external ear. *d*, Entrance to the auditory canal. *f*, Auditory canal. *e*, *e*, Petrous portion of the temporal-bone, in which the internal ear is excavated. *g*, Membrane of the tympanum. *h*, The tympanitic cavity or drum of the ear. (For the relative positions of these bones, see fig. 54, page 167.) *i*, Cells excavated in the temporal-bone. *j*, Opening from the ear-cavity into these cells.—On the side of the cavity opposite the membrana tympani, are seen the fenestra ovalis and rotunda, which open into the vestibule. *l*, The vestibule. *k*, The Eustachian tube. *m*, Semi-circular canals. *n*, Cochlea. *o*, Auditory nerve. *p*, Canal, by which the carotid artery enters the skull. *q*, Part of the glenoid fossa, which receives the head of the lower-jaw. *r*, Styloid process of the temporal-bone.

FIGURE 4.——*A magnified representation of the Labyrinth, laid open, so as to display its Cavity.*—*a*, The vestibule. *b*, The cochlea. *c*, The partition by which the cochlea is divided into two parts. *c*, The fenestra ovalis. *d*, The fenestra rotunda. *f*, *f*, *f*, The semi-circular canals. *g*, Portion of the temporal-bone.

FIGURE 5.——*Capillary Plexus of Papillæ of Human Tongue.*

FIGURE 6.——*Tongue of a Woodpecker.*

FIGURE 7.——*Tongue of a Giraffe,*

Fig. 1

Fig. 3.

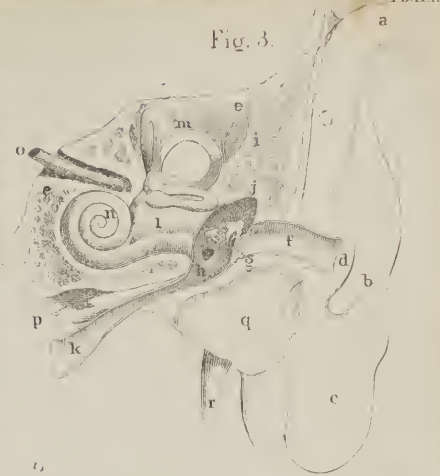


Fig 2.

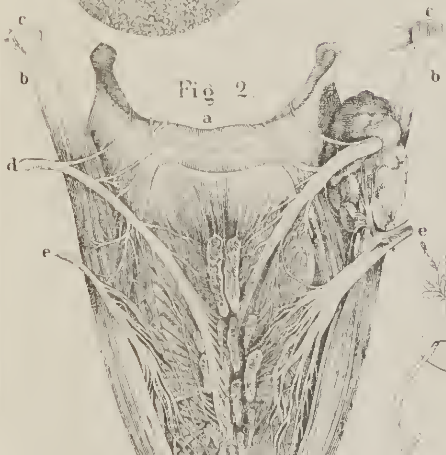


Fig 5.

Fig 7.

Fig 6

Fig. 4.

their wants. Man is guided more by reason than by instinct, and his taste is very much influenced by habit. Thus, many substances that are exceedingly disgusting at first, become by use highly grateful. Innumerable instances of those acquired tastes are observed in all ages, and in every state of society. Thus, epicures in various stages of civilization make use of meat, fish, and eggs, after decomposition has commenced, or after those articles of food are in what is called a "ripe condition;" and multitudes, from all classes of society, chew tobacco, the most disgusting of all weeds, as a sweet morsel.

335. The susceptibility of the organs of taste to pleasurable sensations, depends very much on the condition of the stomach, even in health. Accordingly, the relish or the pleasure with which we partake of any particular article of food, diminishes as hunger is appeased. If indulgence of the appetite is persisted in beyond the actual demand for food, nausea or disgust will very soon supervene, and compel even the glutton to desist. The sympathy subsisting between the organ of taste and the stomach, is an important and wise provision, informing us when a sufficient amount of food has been taken.

SENSE OF SMELL.

336. Smell is the sense by which we perceive odors. Certain bodies seem to possess the property of diffusing through the air in extreme minuteness the particles of which they are composed, and of exciting a peculiar sensation in the organ of smell. Those particles which emanate from odorous bodies are so exceedingly minute, that many

How is man guided? How do substances naturally loathsome come to be agreeable? What examples are given? Upon what does the susceptibility of the organs of taste to pleasurable sensations depend? What ensues if indulgence of the appetite is persisted in beyond the actual demand for food? What is said in regard to the sympathy of the organ of taste with the stomach? What is smell? What properties do certain bodies seem to possess? What is said of the particles which emanate from odorous bodies?

substances do not seem to lose weight by freely imparting their scent to an unlimited quantity of air. Musk, for instance, will impart its scent to a room that is constantly open for many years, without any appreciable diminution of weight. But there are other bodies, such as camphor, which lose weight by loss of particles from their surface when freely exposed to the air.

337. The special seat of the sense of smell is in the thin and delicate membrane which lines the internal surfaces of the nasal cavities. It is called *Schneiderian membrane*, from the man who first described its structure.

338. The acuteness of this sense seems very nearly in proportion to the amount of Schneiderian membrane, or to the extent of surface which the nasal cavities present.

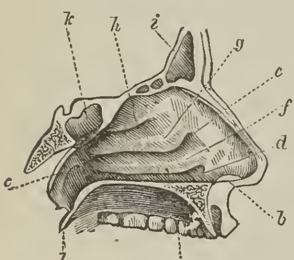


Fig. 52.—VERTICLE SECTION OF THE NASAL CAVITY.—*a*, mouth; *b*, nostril; *c*, posterior opening; *d*, *e*, passages between the spongy bones; *f*, *g*, *h*, spongy bones; *i*, frontal sinuses; *k*, sphenoidal sinuses; *l*, vail of the palate.

Hence, in all those animals remarkable for acuteness of scent—as the deer, sheep, and dog—the nose is very large, and its internal surface greatly increased by the curiously convoluted form of the internal or turbinated bones. *Fig.* 52 is a vertical section of the nasal cavities in man, showing how this membrane is increased in surface by the turbinated bones, *f*, *g*, *h*.

339. When air charged with odorous particles passes over the Schneiderian membrane, in the act of ordinary respiration, or in the voluntary efforts of snuffing air, some

How long will musk scent a room without any apparent loss of its particles? What is said of bodies which lose weight by loss of particles? Where is the special seat of the sense of smell? What is the membrane called? The acuteness of this sense is in proportion to what? What is said of the size of the nose in those animals which are remarkable for acuteness of smell? How is the interior surface of the nose greatly increased? Explain the manner in which the odorous particles are made to act on the Schneiderian membrane?

of the particles come in contact with it, and act upon the delicate extremities of the olfactory nerves, with which the membrane is thickly set. If this membrane is either too moist or too dry, the odorous particles make no impression on it. Thus, in colds or in fevers, the sense of smell is almost entirely lost for the time.

340. All animals do not perceive the same odors equally well. Carnivorous animals excel in detecting the odors of animal substances, and in tracking other animals by the scent, but have no apparent sensibility to the odors of plants and flowers. Herbivorous animals are peculiarly sensitive to the latter, but their sensibility to animal odors is much less acute. Some herbivorous animals, however, possess very great acuteness of smell in regard to animal odors. Thus, the deer and the antelope frequently scent the approach of the hunter, and make their escape, unless he steals upon them in a direction contrary to that of the wind. In this class of animals, the sense of smell seems to be an important means by which they are warned of the presence of their enemies.

341. Herbivorous animals undoubtedly require an acute susceptibility to the odors of plants, to guide them in selecting their food from a variety of plants, some of which are highly deleterious, if not destructive, to animal life.

342. The wonderful scent of the dog is well known. The certainty with which he detects the foot-steps of animals, long after they have passed—the facility with which he traces the progress of his master through crowded streets, recognizing the emanations which his foot has left among all the diversity and multitude of odorous particles—is truly astonishing. In like manner, the deer-hound

Under what circumstances do the odorous particles fail to make any impression? Do all animals perceive the same odors equally well? In what do carnivorous animals excel?—in what herbivorous? What is said of the deer and antelope? Of what special use does the sense of smell seem to be to this class of animals? How do the herbivorous animals seem to be guided in selecting their food? What is said of the scent of the dog?—the deer-hound?

pertinaciously pursues his victim, and follows its traces through the herd of its fellows, among which it vainly seeks for protection.

343. Birds and fishes do not in general possess the sense of smell in as high perfection as quadrupeds, though they do not appear to be entirely destitute of it. Many insects are able to distinguish odorous substances at considerable distance; but physiologists are not agreed as to the location of the organs of smell.

344. Like all the senses, that of smell is greatly improved in acuteness by education. In the blind, especially, it becomes next to that of touch, the sense on which they place the greatest reliance, and by which they distinguish individuals from each other. The Indians of Peru, according to Humboldt, can ascertain by the smell, in the middle of the night, whether a visitor be an European, an American, an Indian, or a Negro. Sometimes the smell becomes morbidly sensitive: there are those who sicken at the scent of cheese, or faint at that of a cat. An eminent French physician was exceedingly annoyed during an illness, in which his smell became remarkably acute, by the odor of copper; and after a careful search, the source of his annoyance was found to be a brass pin, which had fallen among the bed-clothes.

SENSE OF HEARING.

345. Hearing is the sense by which we perceive sounds. The ear is the special organ of hearing, though all the parts which are found in the higher orders of animals are not essential to constitute an organ of hearing. The essential part of this organ is a nerve, endowed with the peculiar property of receiving and transmitting to the

What is said of the sense of smell in birds and fishes?—what of insects? How may the sense of smell be improved? How is it in the blind? What is said of the Indians of Peru? What examples are given in which this sense has become morbidly sensitive? What is hearing? What is the special organ of hearing? What is the essential part of this organ?

brain the impressions derived from the vibrations of the air or water with which the animal is surrounded.

346. Thus, in some of the lower animals—as the crab, lobster, &c.—the ear consists of a cavity in the side of the head, lined with a membrane on which the nerve is distributed, and filled with a watery fluid. In some, this cavity is completely shut in by its bony walls, and in others there is a small aperture covered by a membrane, upon which the external medium can act. This cavity, which corresponds with the vestibule in higher animals, is the whole organ in lower animals; it is the essential part in all, and is never omitted in the most perfect developments of the organ.

347. All other parts may be regarded as superadded to the vestibule, to render this essential organ more perfectly adapted to the wants of each group of animals. Thus, in the lowest fishes, a single semi-circular canal is superadded to the vestibule; a little higher, there are two; and in all other fishes, three semi-circular canals. In animals which live in the air, there are added other parts, which adapt the organ more perfectly to this element.

348. In man, and most of the mammalia, we find the ear composed of three parts—the *external*, the *middle*, and the *internal* ear.

349. The external ear is a fibro-cartilaginous appendage, placed on the outside of the head, to receive and conduct the sounds to the interior. In most of the quadrupeds, the external ear is very large, and capable of being turned in any direction at the will of the animal, as in the horse,

Describe the ear, as found in the crab, lobster, &c.? How is it inclosed in some species? With what in higher animals does this cavity correspond? Is this part ever omitted in the most perfect development of the organs? What may all other parts be regarded? What parts are added in fishes? What other parts are added in animals which live in the air? Of how many parts is the ear composed in man and most of the mammalia? What are these parts? Describe the external ear. What peculiarity has it in most of the quadrupeds? Do men ever possess the power of moving the external ear?

deer, and hare. Some men also possess the power of moving the external ear, though to a very limited extent.

350. Persons who are partially deaf may make use of ear-trumpets, by which the vibrations of sound are collected from a greater extent of surface, and thereby act with greater intensity on the drum of the ear; or, in case this is destroyed, on the internal ear.

351. The canal (*fig.*3, Pl. XIII.) into which the external ear collects the sonorous vibrations, passes inwards until it is terminated by the tympanum or the membrane of the drum of the ear, which separates the external from the middle ear. This canal is about an inch in length, and is protected from the entrance of insects and dust by short hairs, which grow across the tube.

352. In reptiles and birds, there is no external ear, and the tympanum is found on the surface of the head, where it can be easily seen, just back of the eye, as in the frog. In birds, it is found in a slight depression in the head, surrounded by a tuft of feathers. In man, it is a rough, tense membrane, stretched across the auditory passage, in a manner similar to the parchment on a drum, with its edges set in a bony groove.

353. The *middle ear*, which is also called the *tympanitic cavity* or *drum* of the ear (*h*), is an irregular bony cavity, filled with air. It communicates with the external air by means of the Eustachian tube, which terminates in the back part of the throat. The use of this tube seems to be to produce an equilibrium between the air contained in the drum of the ear and the external ear. In severe colds,

What may be made use of to collect the vibrations of sound by persons who are partially deaf? What effect does it have on the vibrations of sound? What is said of the canal into which the external ear collects the sonorous vibrations? How is it separated from the middle ear? What is its length? How is it protected from insects? Have reptiles and birds any external ear? Where is the tympanum formed in frogs?—in birds? Describe it in man. What other name is applied to the middle ear? With what is it filled? How does it communicate with the external air? Where does this tube terminate? What is its use? What effect do colds sometimes have on this tube?

this tube is frequently obstructed, causing "ringing in the ear," confusion of sound, and partial deafness.

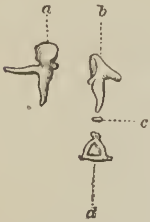


Fig. 53.—BONES OF THE EAR.

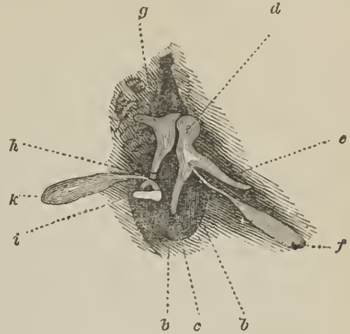


Fig. 54.—CAVITY OF THE TYMPANUM, WITH THE BONES IN THEIR PLACES.

354. Within the drum of the ear (*fig.* 3, PL. XIII.) there is a very curious arrangement of small bones, which connect the tympanum to the membrane of the internal ear. These bones, which are represented in *figs.* 53 and 54, are so arranged as to form a continuous chain of bones. When the tympanum vibrates, they move backward and forward in such a manner that the slightest vibration is communicated to the membrane of the internal ear. In birds and reptiles, instead of a chain of bones, there is a single bone, with one extremity attached to the tympanum and the other to the membrane that incloses the internal ear. This bone can easily be seen pressing against the tympanum in the ear of a bird by removing the skin and feathers from the head.

355. The internal ear or labyrinth is composed of three cavities—the *vestibule*, the *semi-circular canals*, and the *cochlea.*

What peculiar arrangement within the ear? How are these bones arranged? How do they move with the vibrations of the tympanum? What substitute for a chain of bones do we find in birds and reptiles? How can this bone be seen in the ear of a bird? How many cavities has the internal ear?

356. The vestibule (porch or entrance) corresponds with the simple sac that constitutes the whole organ of hearing in the lower animals, and is the essential part in all. It is separated from the middle ear by a bony partition, which is perforated by two small holes, called, from their form, *foramen ovale* (oval opening), and *foramen rotundum* (round opening). The first is closed by a membrane, on which the stapes, one of the small bones, rests, and the other by a membrane similar to the tympanum.

357. The semi-circular canals are passages running off from the upper part of the vestibule, in the form of three arched tubes. These canals are found in fishes, and in all animals which live in the air. Their use is supposed to be to assist in producing an idea of the direction of sounds.

358. The cochlea, so called from its resemblance to a snail-shell, is a spiral canal, running off from the lower part of the vestibule. It is peculiar to those animals which live in the air, and has been supposed to be the organ by which we judge of the pitch of sounds. It also affords a greater extent of surface for the spreading out of the nervous fibres.

359. All the above cavities of the internal ear are lined with a delicate membrane, on which the extremities of the auditory nerve are minutely distributed, and are filled with a watery fluid, in which filaments of the nerve are also found floating. These terminations of the auditory nerve constitute the real organ by which impressions of sound are received and transmitted to the brain. The

With what does the vestibule correspond? How is it separated from the middle ear? How is this partition perforated? How are these openings closed? What are the semi-circular canals? In what animals are those canals found? What is their use? From what does the cochlea derive its name? What is the form and position of the cochlea? To what class of animals is it peculiar? What has been supposed to be the use of the cochlea? How are the cavities of the internal ear lined? What is distributed on this membrane? With what are these cavities filled? What constitutes the real organ by which impressions of sound are received and transmitted? How are the vibrations of sound communicated to the nerve?

vibrations of sound are communicated to the nerve through the medium of a watery fluid.

360. Sound travels through the air at the rate of about twelve and a half miles in a minute; through water, its velocity is four times greater; and the intensity of the vibrations of sound in air and water are in about the same proportion.* Hence, the impressions of sound on the nerves which are the immediate seat of hearing are much more intense in the watery fluid, which fills the cavities of the internal ear, than they could be if those cavities were filled with air. For the same reason, animals which live in the air require an apparatus for hearing more complicated than those animals which live in the water. Accordingly, we find in those animals which live in the air, the addition of just those parts that would communicate the vibrations of sound from the air to the fluid of the internal ear with the greatest intensity. Thus, a tense membrane, like that of the drum of the ear, with air on both sides, is better adapted than any other animal structure to receive the vibrations of the air; and the arrangement of the bones which connect this membrane with that of the internal ear, is equally well fitted for the office of conducting those vibrations to the fluid of the internal ear.

361. Still, the faculty of hearing will not be entirely lost if the drum of the ear is destroyed, so that the vibrations of sound act directly on the membrane of the internal

At what rate does sound travel through the air? What is its velocity through water? What advantage then is gained by the nerves receiving impressions through water instead of air? Why do animals which live in air require an apparatus more complicated than those which live in water? What parts do we find added in those animals which live in air? What is said in regard to the adaptation of the tympanum and the bones which connect it to the internal ear to receive the vibrations of the air? Will the faculty of hearing be entirely lost if the drum is destroyed? How will the hearing be affected by its loss?

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* The difference in the intensity of the vibrations of sound in air and water may be easily perceived by striking two stones together with equal force—first in the air and then under water, with the head immersed.

ear, though it will be greatly impaired, rendering the individual partially deaf.

362. The faculty of hearing may be very much increased in acuteness by cultivation; but this increase depends rather upon the habit of attention to the faintest impressions made upon the organ, than upon any change of the organ itself. Thus, the watchful Indian, recognizes footsteps, and can even distinguish the tread of a friend from that of a foe, while his white companion, who lives among the busy hum of cities, is unconscious of such slight sounds. Yet the latter may be a musician, capable of distinguishing the tones of all the different instruments in a large orchestra—of following any one of them through the part which it performs—and of detecting the least discord in the blended effects of the whole—effects which would be to the Indian only a confused mass of sound.

SENSE OF SIGHT.

363. Sight is the sense by which we are enabled to perceive luminous impressions; and through these we become acquainted with the form, size, color, and position of objects that transmit or reflect light.

364. The eye is the organ of sight. It consists essentially in an instrument capable of making a distinct picture of surrounding objects on the expanded surface of the nerve of sight.

365. Some of the inferior animals, such as the leech, seem to be guided in their movements by certain dark spots on their surface, supposed to be rudimentary eyes, though no fully developed eyes have as yet been discovered. In some of the star-fishes those eye-spots are found at the extremity of the rays, as in *fig.* 1, Pl. XVI.

How may the faculty of hearing be increased in acuteness? Upon what does this increase seem to depend? What examples are given of the habit of attention? What is sight? What is the organ of sight? In what does it consist essentially? How do some of the inferior animals seem to be guided in their movements?

PLATE XIV.

ORGANS OF VISION—THE EYE.

FIGURE 1.——*The Left Eyeball, showing the Posterior Surface of the Retina.*—*a*, A small transparent spot, situated near the optic nerve, called the foramen of Soemmering, surrounded by a yellow halo, the *limbus luteus*. *b*, The optic nerve, cut off at its entrance into the retina. *c*, The central artery of the retina. *d*, *d*, Ramifications of the artery on the inner wall of the retina, seen through the outer layers.

FIGURE 2.——*The Globe of the Eye, magnified, and seen in front.*—This figure represents the second or choroid coat, the sclerotica being removed. *a*, The pupil. *b*, The iris. *c*, *c*, The choroid membrane. *d*, *d*, The ciliary nerves, running from every part of the circumference towards the iris. *e*, *e*, The ciliary arteries.

FIGURE 3.——*The Globe of the Eye, seen in the same view.*—The iris is removed, in order to display the ciliary processes, and their position in regard to the lens. The ciliary nerves and arteries are the same as in fig. 2.

FIGURE 4.——*The Anterior Half of the Globe of the Eye, seen from behind.*—The lens and the vitreous humor are removed. *a* The pupil. *b*, *b*, The posterior surface of the iris, called, from its dark grape-like color, *uvea*. *c*, *c*, The ciliary processes. *d*, *d*, The internal surface of the choroid and sclerotic

FIGURE 5.——*The Posterior Half of the Globe of the Eye, showing its internal surface.* —*a*, *a*, The cut edges of the sclerotic, choroid, and retina. *b*, *b*, The internal surface of the retina. *c*, The foramen of Soemmering. *d*, The optic nerve. *e*, Branches of the central artery of the retina.

FIGURE 6.——*The Fibres of the Iris, detached.*—*a*, The pupil. *b*, The circular fibres at the central margin of the iris, by the action of which the pupil is diminished or enlarged. *c*, *c*, The radiating fibres, which proceed from the external border of the circular fibres.

FIGURE 7.——*A Portion of the Pigment Membrane of the Choroid Coat, highly magnified.*—It is seen to consist of regular six-sided plates, the tissue of which is filled with grains of coloring matter.

FIGURE 8.——*Compound Eyes of the Bee, highly magnified, showing the Division into Facets, and also the Conical Shape of each separate Portion.*—*A*, Facets still more highly magnified. *B*, The same with hairs growing between them.

FIGURE 9.——*A*, *Front View of the Crystalline Lens.*

FIGURE 10.——*Side View of the Crystalline Lens.*—*a*, Its anterior and least convexity. *b*, Its posterior and greatest convexity.

FIGURE 11.——*The Crystalline Lens, after being immersed in boiling water.*—The lines on its surface show its division into three parts.

FIGURE 12.——*The Three Segments of the Crystalline Lens.*—The faces of the segments show the concentric layers of which it is composed (like the coats of an onion). The nucleus, or central portion of the lens, is seen on one of the segments, and on the other two are corresponding depressions.

PL. XIV

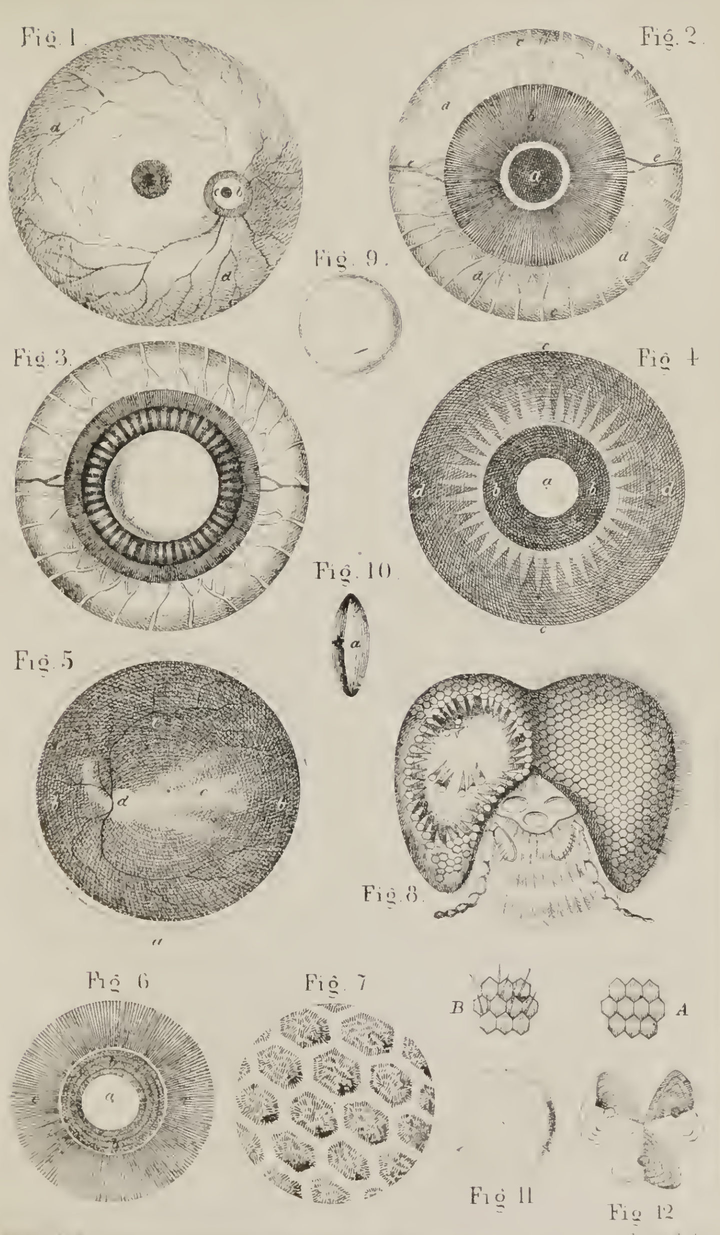

Fig. 1.
Fig. 2.
Fig. 3.
Fig. 4
Fig. 5
Fig. 6
Fig. 7
Fig. 8.
Fig. 9.
Fig. 10.
Fig. 11
Fig. 12
A
B

366. Most insects are furnished with compound eyes, which consist of several hexagonal facets, (*fig.* 8, Pl. XIV.) united together in such a manner as to form a large, dark-colored protuberance on each side of the head. Each of these facets is an eye in itself. In some insects, these facets are exceedingly numerous. In the eye of a butterfly, 17,000 have been counted; in some species of beetle, 25,000; in the common horse-fly, 4,000. These numerous eyes, no two of which have the same direction, seem to compensate for the inability of the insects to move the head without moving the whole body, since they are provided with an eye in every direction.

367. Spiders are furnished with from six to fourteen eyes, situated on the most prominent part of the back, instead of on the sides of the head. (*Fig.* 3, Pl. XVI.)

368. In the snail and some other mollusks there are only two eyes, situated on or near the tip of a flexible stalk—the tentacula, (*fig.* 2, Pl. XVI.) which can be extended in any direction at the pleasure of the animal. In lobsters and crabs the eye is placed at the extremity of a long tube, which can be moved in various directions, and extended or withdrawn.

369. In all the higher animals there are only two eyes, which are constructed on the same general plan, with some variation in the form of particular parts, adapting the eye to the medium with which different animals are surrounded.

370. The form of the eye is nearly globular in all, and placed in a bony socket (the orbit) in the head. The orbit is lined with a cushion of fat, on which the eye rests and rolls with very great ease. When a person becomes very

With what are most insects provided? Of what are those compound eyes made up? What is each facet? How numerous are these facets? How many in the eye of a butter-fly—in the beetle? What seems to be the use of so large a number? With how many eyes are spiders provided? How many eyes are there in the snail, and how are they situated? How is the eye placed in crabs and lobsters? How many eyes are there in all the higher animals? What is the form of the eye, and how is it placed? How is the orbit lined?

much emaciated, this cushion of fat is gradually absorbed, allowing the eye to recede into the orbit.

371. The eye is admirably protected against insects, dust, and other foreign substances, by the eye-brows, eyelids, and eye-lashes.

372. In birds and reptiles there is a thin transparent membrane which is drawn across the eye by a muscle that passes through a loop in the membrane, (*fig.* 4, Pl. XVI.) This nictating membrane is so transparent as not to prevent the power of vision, while it protects the eye from too strong light, and guards it against foreign bodies.

373. The horse is provided with a beautiful contrivance for protecting the eye, called the *haw*. It is a triangular-shaped cartilage, admirably adapted to the convexity of the eye, and so arranged that it is made to sweep across the eye at the will of the animal, and shovel up any dust or insect that may fall upon it.

374. The anterior surface of the eye is covered by the conjunctiva—a thin mucous membrane, which is reflected upon the lids, so as to form their internal surface.

375. The conjunctiva is constantly moistened by the mucus from its surface, and by the tears that are secreted in the lachrymal glands, and poured upon the inner surface of the upper lid by seven or eight tubes. The lachrymal gland (*fig.* 2, Pl. XV.) is situated at the upper or outer angle of the orbit. It is continually pouring out a watery fluid, which moistens the globe of the eye, and keeps it free from impurities. This secretion is increased by mental emotion, and by irritation of the eye. The tears pass out from the eye by two lachrymal ducts, which

What takes place when a person becomes very much emaciated? How is the eye protected against insects, dust, &c.? What membrane is there in birds and reptiles? How is it drawn across the eye? How does it protect the eye without preventing sight? With what is the horse provided? Describe the haw? How is the interior surface of the eye covered? How is the conjunctiva moistened? Where is the lachrymal gland situated? What is continually pouring out from this gland? How is this secretion increased? How do the tears pass out of the eye?

PLATE XV.

ORGAN OF VISION.—THE EYE.

FIGURE 1.——*Both Eyes, with their Muscles*, as they appear upon a horizontal section through the orbits, immediately above the eyes—as if the upper part of the head were removed, as far down as the top of the eyes, the observer looking at them from above. They are represented in this position, in order to show clearly the situation and action of the superior oblique muscle, and also the crossing or decussation of the optic nerve. The letters of reference indicate the same parts in figures 1 and 3.

a, The optic nerve. *s*, figure 1, The chiasma or commissure of the optic nerve, whence each nerve extends forward and outward, passes into the eye at *t*, and becomes continuous with the retina. *b*, The common oculo-motory nerve, which is distributed to five of the muscles of the eye. *k*, Trunk of the fifth pair, a branch of which constitutes the ophthalmic nerve, and gives sensibility to the different parts of the eye.—The distribution of this nerve is seen in the left eye in figure 1. *l*, Artery of the eye. *c*, The elevator muscle of the upper eyelid. *d*, The superior rectus, or elevator of the eye. *e*, The inferior rectus, or depressor of the eye. *f*, The internal rectus. *g*, The external rectus. *h*, figure 1, The superior oblique muscle. *m*, Its pulley. *i*, figure 3, The inferior oblique muscle. In figure 1, parts of several of these muscles are removed, in order to display the others distinctly.

FIGURE 2.——*The Lachrymal Apparatus.*—*a*, The lachrymal gland. *b*, *b*, The lachrymal ducts, which collect the tears, and transmit them to the lachrymal sac, *c*, whence they pass into the cavity of the nose.

FIGURE 3.——*The Right Eye, with its Muscles*, displayed in the cavity of the orbit, on the vertical plane of a section corresponding to the middle of the arch of the eyebrow:—that is, as if the right side of the head were removed, as far as the middle of the right eyebrow, leaving the eye in its place, to be seen from the right.

PL. XV

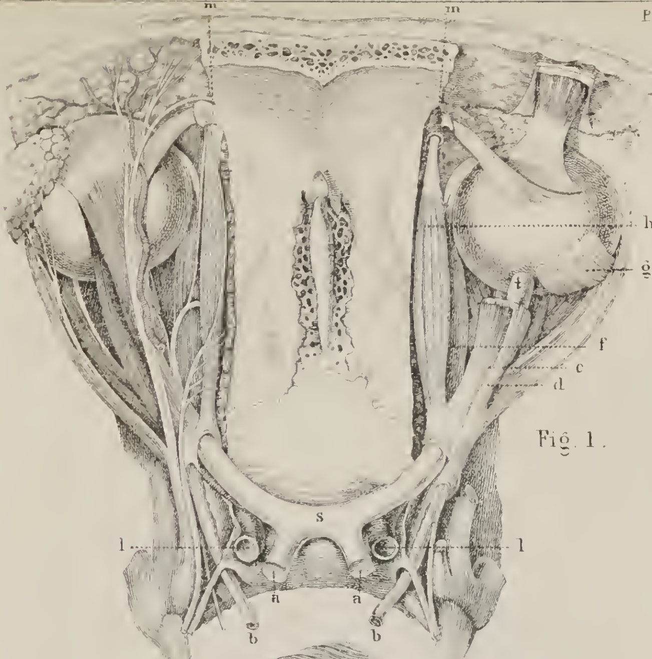

Fig. 1.

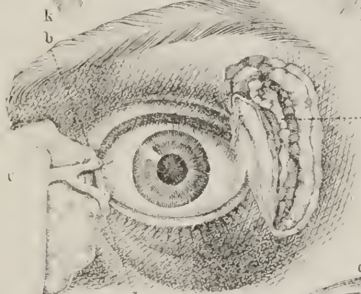

Fig 2

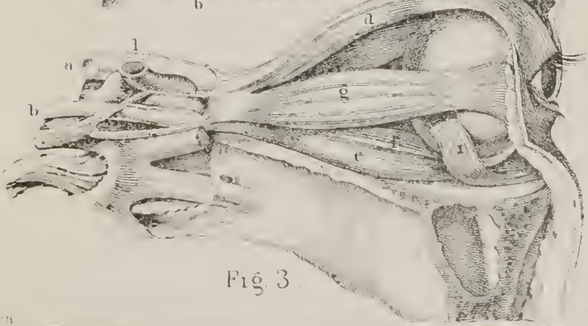

Fig. 3

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commence in a small opening in the edge of each lid, near the corner of the eye, and unite to form the lachrymal sac that lies upon the side of the upper parts of the nose. From the lachrymal sac a canal passes down to the interior of the nose, where the tears pass off in vapor with the breath.

376. The walls of the eye are composed of three coats: the *sclerotic*, the *cornea*, and the *choroid coat*. Its interior is occupied by three humors: the aqueous, the crystalline, and the vitreous.

377. The *sclerotic*, (*fig.* 55,) so named from its firmness and density, constitutes about four-fifths of the globe of the eye. It is a tough fibrous structure, admirably adapted to protect and support this delicate organ.

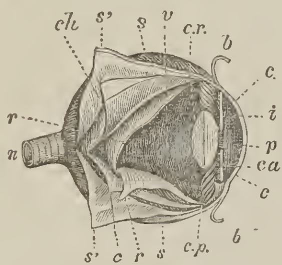


Fig. 55.—INTERIOR OF THE EYE.

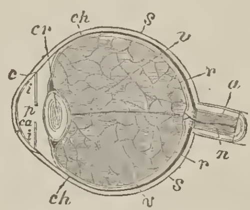


Fig. 56.—SECTION OF THE EYE.

c, cornea; *s*, sclerotic; *s'* portion of the sclerotic turned back to show the subjacent parts; *ch*, choroid; *r*, retina; *n*, optic nerve; *ca*, anterior chamber; *i*, iris; *p*, pupil: *cr*, crystalline lens; *cp*, ciliary processes; *v*, vitreous humor; *b*, *b*, conjunctiva.

378. The *cornea* (*c*, *fig.* 55) is a dense transparent structure, convex in front and concave posteriorly. It resembles a watch-glass in form, and is received into a circular groove in the margin of the sclerotic, in the same manner that a watch-glass is inserted into the case. It occupies about one-fifth of the front part of the eye, and projects forward beyond the sclerotic. In some individuals and

Where is the lachrymal sac situated, and how do the tears escape from it? Of what are the walls of the eye composed? How is its interior occupied? Describe the sclerotic. Describe the cornea. How is it received into the sclerotic? What portion of the eye does it occupy? What is said in regard to its prominence at different periods of life and in different animals?

in some animals it is more prominent than in others, and it is also more prominent at some periods of life than at others. In fishes, and in some water-birds, it has only a slight projection forward, as represented in *figs.* 5 and 6, Pl. XVI.

379. The *choroid coat*, (*ch*, *fig.* 55,) which is a thin, delicate structure, consisting mostly of blood-vessels and nerves, lines the interior of the sclerotic. The internal surface of the choroid is covered by a layer of black pigment cells. (*Fig.* 7, Pl. XIV.)

380. The aqueous humor, which occupies the anterior chamber of the eye, (*fig.* 56,) is nearly pure water. It gives prominence to the cornea, causing it to be more or less convex, according to the amount of this fluid.

381. The vitreous humor, which resembles thin jelly or melted glass in consistence, occupies the greater part of the globe of the eye behind the iris.

382. The crystalline humor resembles thick jelly or soft gristle. It has the form of a double-convex lens, whence it has received the name of crystalline lens. In those animals which have only slight projections of the cornea, it is nearly spherical. (*Figs.* 5 and 6, Pl. XVI.) It is suspended in its place by the ciliary process, (*fig.* 3, Pl. XIV.) a set of little bands from the choroid coat.

383. The aqueous and vitreous humors are separated from each other by the iris, (*fig.* 2, Pl. XIV.) a kind of curtain, which divides the anterior from the posterior chamber of the eye. The iris receives its name from the great variety of its colors. It is perforated in the centre by an opening, called the *pupil.* (*Fig.* 2, Pl. XIV.) In man, this pupil is round, and dilates or contracts according to the amount of light and the sensibility of the optic nerve.

What fluid occupies the anterior chamber of the eye? How does it affect the form of the cornea? Describe the vitreous humor—the crystalline humor. What is the form of it? How is it suspended in its place? How are the aqueous and vitreous humors separated from each other? From what does the iris receive its name? What opening has the iris in the centre? What is the form of the pupil in man?

When the light is very strong, it is but a speck, and enlarges to nearly half the size of the iris in the dark. In birds, especially in owls, its motions are more free and extensive than in man.

384. The blackness of the pupil is owing to the dark color of the internal surface of the choroid. In Albinoes, which are destitute of coloring matter, the pupil, as well as the iris, are a bright red, from the numerous capillary blood-vessels of the choroid. In many quadrupeds—as the ox, the lion, and the cat—a portion of the surface of the choroid is covered with a bluish layer of bright metallic lustre, by which the light is brilliantly reflected, when the eye is seen in certain directions, causing the eyes to appear in an obscure light *like two balls of fire.*

385. In animals whose range of vision is required to extend widely in a horizontal direction—as in the deer, cow, &c.—it is lengthened horizontally, so as to give a wide side-view. In the carnivorous animals—as the lion, cat, &c.—which watch their prey in situations either above or below them, the pupil is elongated vertically.

386. Inside of the choroid coat, and at the back part of the eye, is the retina, which consists of a delicate film of nervous fibres, spread out from the optic nerve as soon as it has passed through the sclerotic and choroid coats.

387. The globe of the eye is moved by six muscles—four *recti* or straight, and two *oblique*—all of which are lodged in the orbit. The superior rectus or straight muscle (*fig.* 3, Pl. XV.) rolls the eye upward, and the inferior rectus turns it downward. The internal rectus rolls the globe inward, or toward the nose, and the external

How does it vary in size? To what is the blackness of the pupil owing? What is the color of the pupil and iris in albinoes? What peculiar appearance has the eye in many quadrupeds? What is the form of the pupil in grazing animals?—in carnivorous animals? What is situated inside of the choroid coat? Describe the retina. How is the globe of the eye moved? How does the superior rectus move the eye?—the inferior rectus?—the internal rectus?—the external rectus?

rectus turns it outward. The superior oblique, a very remarkable muscle, has its origin at the back of the orbit, passing forward through a little cartilaginous pulley, and then turning backward, to be inserted into the sclerotic coat. The direction of its action is thus changed, like that of a rope which is passed through a block in an ordinary pulley. The use of this muscle is to roll the eye downward and inward. The inferior oblique turns it upward and outward.

388. The coats and humors of the eye seem admirably adapted to modify the rays of light, which fall on the nerve of sight in such a manner as to make the impression clear and distinct. All the parts of the eye are constructed in such strict accordance with the laws of light, that it excels all other optical instruments in perfection and accuracy. Human skill has thus far effected only an imperfect imitation of the instrument designed by Infinite Wisdom.

389. It is well known that when the rays of light pass obliquely from the air through a dense medium, they are refracted or bent out of their course, as in *fig.* 7, Pl. XVI., and that the refraction is in proportion as the rays fall more or less obliquely. Thus, if a piece of money be placed in a cup (*fig.* 57) in such a position that the side of the cup will just hide the money from sight, and then let the cup be filled with water, the money will be distinctly visible from the refraction of the rays of light. For the

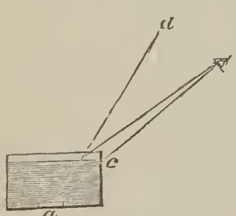


Fig. 57.

Describe the superior oblique? What is the use of this muscle? In what direction does the inferior oblique turn the eye? To what do the coats and humors of the eye seem adapted? How does the eye compare with optical instruments? How are the rays of light affected by passing obliquely from a rarer to a denser medium? The refraction is in proportion to what? What examples are given, illustrating the refraction of the rays of light in passing from air to water?

PLATE XVI.

ORGANS OF VISION—THE EYE.

FIGURE 1.——*Eye-spots of a Star-fish*, at the extremities of the radii.

FIGURE 2.——*Eyes of a Snail*, on the extremities of the tentaculæ.

FIGURE 3.——*Eyes of a Spider*, on the anterior part of the back.

FIGURE 4.——*Nictating Membrane of a Bird.*—A, Nictating membrane, covering one-half the surface of the eye. B, The muscles by which the membrane is drawn across the eye. The muscle *a* forms a loop at *b*, through which the muscle *c* acts as through a pulley by its tendon *d*, which is inserted into the edge of the nictating membrane at *e*.

FIGURE 5.——*Eye of a Fish*, with very slight convexity of the cornea, and the lens nearly spherical, so as to compensate for the want of refractive power in the anterior part of the eye.

FIGURE 6.——*Eye of a Duck*, with a similar formation.

FIGURE 7.——*Refraction of Light.*—*a*, The ray of light falling obliquely on a dense medium at *b*, is refracted to *c*, instead of pursuing its original course to *d;* when it passes into a rarer medium again at *c*, it is again refracted in a new course down to *d*, instead of *f*.

FIGURE 8.——*The Lenses.*—*a*, Single convex lens. *b*, Single concave lens. *c*, Double convex lens. *d*, Double concave lens. *e*, Concavo convex lens.

FIGURE 9.——*Short-sightedness*—The image formed in front of the retina.

FIGURE 10.——*Long-sightedness*—The image formed back of the retina.

FIGURE 11.——*Eye of a Lynx.*—*a*, Ciliary process, by which the lens, *b*, is moved backward and forward, to adapt it to different distances.

FIGURE 12.——*Eye of an Eagle.*—*a*, Fan-like muscle, attached to the lens, to change its position.

FIGURE 13.——*Eye of an Owl*, surrounded by a kind of bony case, which causes the anterior portion of the eye to become more, and the posterior portion less convex, whenever the eye is drawn back into the socket. By this means the focal distance is changed, and the eye adapted to different distances.

PL. XVI

Fig. 1.

Fig. 2

Fig. 3.

Fig. 4

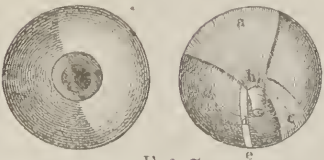


Fig. 5

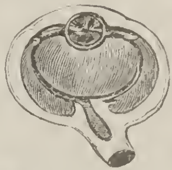


Fig. 6

Fig. 7.

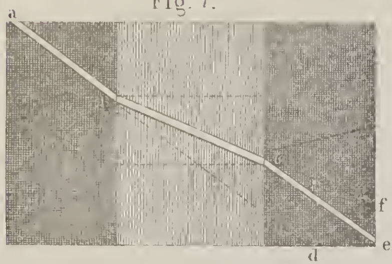


Fig. 11.

Fig. 8

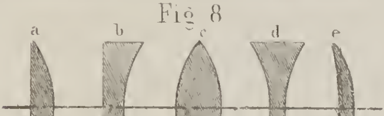


Fig. 12

Fig. 9.

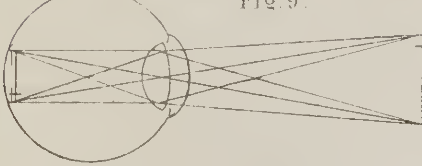
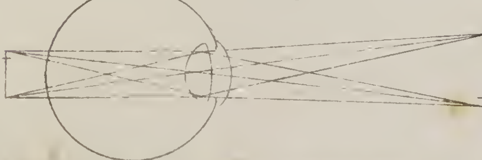


Fig. 13

Fig. 10.



same reason an oar or a stick, when partly immersed in water, will appear bent in proportion to its obliquity.

390. The rays of light which fall upon the cornea of the eye are refracted towards the pupil, both by the density of the cornea and aqueous humor, and by the convexity of the cornea, which causes the rays to fall on it more obliquely.

391. After passing through the pupil, the rays of light continue to be refracted by the crystalline lens and vitreous humor, so that they meet in a focus on the retina, where a complete inverted image or picture of the object is thus formed. This is shown in *fig.* 58, where, for the sake of convenience, two rays only are represented as issuing

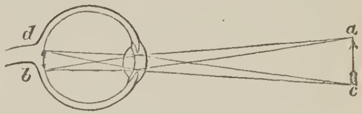


Fig. 58.

from each of the two extremities of an object, *a*, *c*. Those rays cross each other in the middle of the eye—those from *a* being brought to a focus at *b*, and those from *c* at *d*; and as all the other rays are refracted in the same manner, a complete inverted picture of the object is formed at the back of the eye.

392. The inverted image may be easily seen by removing the fat and muscle from the eye of a white rabbit, and bringing a lighted candle in front of it, when an inverted image may be distinctly seen on the retina through the transparent coat of the sclerotic; or it may be seen by removing the sclerotic from the back part of the eye of a sheep or an ox. In either case, the eye should be fresh, as the cornea and humors soon lose their transparency, and the image becomes indistinct.*

How are the rays of light refracted towards the pupil? How are the rays of light affected by the crystalline lens and the vitreous humor? What is the position of the image on the retina? Describe Figure 58. How may the inverted image be seen?

*To show the retina of the eye, clip off the muscular and adipose substance about it, then describe with the knife a circle about the

393. The black pigment, which is situated in the internal surface of the choroid, and immediately behind the retina, absorbs the rays of light as soon as they have passed through the retina, and prevents them from being reflected from one part of the eye to another, causing confusion and indistinctness in the picture. The black pigment also diminishes the intensity of the impression of light on the retina. In Albinoes, (in whose eyes the pigment is deficient,) vision is not only extremely imperfect, but the strong sunlight is even painful to the eye. Hence, Albinoes can see most clearly when twilight comes on, or during cloudy days, or by moonlight.

394. The ordinary forms of defective vision, known as short-sightedness and long-sightedness, are caused by defects in the refractive power of the eye.

395. In short-sightedness, the refractive power is too great, causing the rays to be brought to a focus forward of the retina, unless the object be held very near the eye, so as to increase the angle at which they fall on the cornea. (*Fig.* 9, PL. XVI.) In most cases of short-sightedness, the cornea is too convex from an excess of the aqueous humour.

396. Short-sightedness is frequently caused in students

What is the use of the black pigment on the internal surface of the choroid? How does the light affect the eye in Albinoes? How are short and long-sightedness caused? What is the defect in short-sightedness? What is the form of the cornea in short-sightedness? How is it frequently caused?

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entrance of the optic nerve that shall include one-fourth of the ball of the eye; holding the eye in the thumb and fingers of the left hand, gradually and carefully cut through the sclerotic to the choroid coat, at a single point in the circle already described, and then complete the dissection in water by carefully insinuating the sharp point of the scissors between the coats, and clipping round the circle. The slight attachment of the choroid to the sclerotic may now be separated with the back of the knife till the detached portion of the sclerotic can be clipped off, leaving the nerve entire. The dissection is now complete; and, if well performed, inverted images of objects can be seen on the retina as in life.

and artisans by the habit of holding objects near the eyes, till they adapt themselves to a short focal distance, and it may be remedied by perseverance in the opposite practice. Thus, sailors, from the long habit of using their eyes in search of distant objects, acquire the ability of recognizing objects at a distance that would be unobserved by a landsman.

397. If short-sightedness has continued from birth, it can seldom be remedied, except by the use of concave glasses, the curvature of which compensates for the excess of the convexity of the eye. If the glasses used be too concave, they will increase the difficulty; while those that are not quite concave enough, will have a tendency to remedy it. If glasses can be dispensed with, or if they are changed for those less concave every few years, the difficulty will gradually diminish, till, in advanced life, the eye assumes the natural form.

398. In long-sightedness, (*fig.* 10, Pl. XVI.) which is commonly met with in persons in advanced life, the refractive power of the eye is not sufficient to bring the rays to a focus on the retina, but back of it, unless the object be held at a long distance from the eye. At this period the eye is not sufficiently convex, from the decrease of its fluids. This difficulty may be remedied by perseverance in the habit of holding objects as near the eye as possible, or wearing spectacles with convex glasses, which shall compensate for the deficiency of the convexity of the eye.

399. The eye is the most delicate of the organs of sense, and is more liable to disease than any other. In many persons the conjunctiva is exceedingly sensitive, and

How may short-sightedness be remedied? What power do sailors acquire by the habit of viewing objects at a distance? What kind of glasses may be used to remedy short-sightedness? What will be the effect of using glasses that are too concave?—not quite concave enough to compensate for the convexity of the eye? How does the eye gradually return to its natural form? What is the cause of long-sightedness? What change in the eye diminishes its convexity? How may the difficulty be remedied? What is said in regard to the liability of the eye to become diseased?

becomes inflamed from very slight causes. Exposure to dust, to wind, or to a strong light, not unfrequently induces severe inflammation. The optic nerve is also liable to serious injury from exposure to a strong light, from too protracted application to study, or from using the eyes with insufficient light. Disease of the eyes may be prevented by a careful regard to their strength, by refraining from their use in improper light, and by affording them rest as soon as a sense of fatigue begins to be experienced. Moderate ablution at bed-time, and liberal washing in cold water on rising in the morning, will be found of great service in promoting strength and vigor.

CHAPTER XIII.

ANIMAL MOTION.

400. The power of voluntary motion is characteristic of all animals.

401. The organs of voluntary motion are the bones and muscles.

402. The bones constitute the frame-work of the body and give strength and firmness to the entire organization

403. The muscles form the greatest part of the mass of the body, and constitute what is commonly known as flesh or lean meat.

404. The principal hard parts in animals are shells, crusts, and bones. Shells are almost destitute of animal matter, being nearly the same in composition as a piece of marble. Crusts, such as the covering of the lobster, contain a considerable quantity of animal matter, though less than is found in bones.

What parts are liable to become inflamed or to be injured by improper use? What causes induce disease? How may disease be prevented? What power is characteristic of all animals? What are the organs of voluntary motion? What do the bones constitute?—what the muscles? What are the principal hard parts in animals? What is the composition of shells?—of crusts?

PLATE XVII.

ORGANS OF MOTION.—THE BONES.

FIGURE 1.——*Front View of the Human Skeleton.*—At the right half of this figure, the bones are represented in their natural connections, and divested of all covering. At the left side, the joints are covered by their ligaments. The outer lines show the form of the body when covered with flesh.

THE HEAD.—*a*, The frontal-bone. *b*, The parietal-bone. *c*, The temporal-bone. *e*, The superior maxillary-bone. *f*, The malar-bone. *g*, The nasal bones. *h*, The vomer. *i*, The inferior maxillary-bone. *k*, The orbits. *l*, *l*, Sutures.

THE TRUNK.—1, 1, The spinal column. 2, The sternum. 3, 3, The ribs. 4, The os innominatum, or haunch-bone. 5, The sacrum.

THE SUPERIOR EXTREMITIES.—6, The clavicle. 7, Acromion process of the scapula, which articulates with the clavicle. 8, The humerus. 9, The elbow-joint. 10, The radius. 11, The ulna. 12, Bones of the carpus. 13, Bones of the metacarpus. 14, The phalanges.

THE INFERIOR EXTREMITIES.—15, The hip-joint. 16, The femur, or thigh-bone. 17, The patella. 18, The tibia. 19, The fibula. 20, Bones of the tarsus. 21, Bones of the metatarsus. 22, Bones of the toes. On the left side of the figure, *l* indicates the ligaments of the shoulder. *m*, Ligaments of the elbow. *n*, Ligaments of the wrist. *s*, Ligaments of the hip-joint. *o*, Ligaments of the knee, and tendon of the extensor muscle of the leg. *p*, Ligaments of the ankle. *q*, Large vein and artery of the arm. *r*, Large vein and artery of the leg.

FIGURE 2.——*A Bone deprived of its earthy portion by maceration in a dilute acid, and tied in a knot* to show its flexibility.

FIGURE 3.——*A Section of the Femur*, showing its cancellous structure.

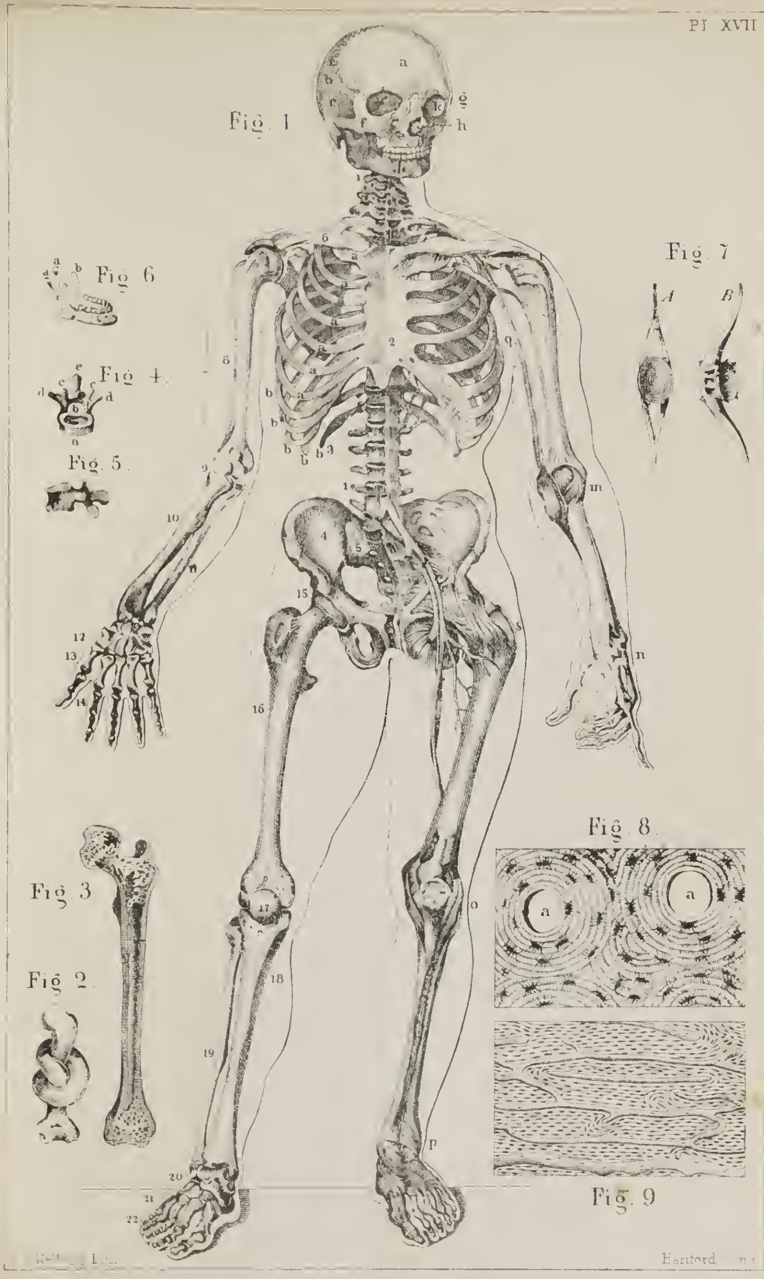
FIGURE 4.——*A Dorsal Vertebra.*—*a*, The body of the vertebra. *b*, The spinal foramen *c*, *c*, Articulating processes. *d*, *d*, Transverse processes. *e*, Spinous processes.

FIGURE 5.——*A Lumbar Vertebra*, to show the greater thickness and strength of its body and processes.

FIGURE 6.——*The Lower Jaw.*—*a*, The condyle, which articulates with the temporal-bone. *b*, The coronoid process. *c*, The ramus.

FIGURE 7.——*Vertebra of a Fish.*—*A*, End view. *B*, Side view of the same.

FIGURES 8 AND 9.——These figures are designed to show the minute structure of bone. Figure 8 represents a cross-section of bone, highly magnified. *a*, *a*, Orifices of small tubes, called, from their discoverer, Haversian canals. They usually run in the direction of the length of the bone, the membrane lining the hollow of which is prolonged into their canals. This membrane contains innumerable small blood-vessels, and the interior of the bone is thus supplied with blood. Around each of the Haversian canals are seen concentric circles of some small dark spots, which are found to be flattened cavities or bone-cells, from which proceed numerous minute tubules. These open into the sides of the Haversian canals, and communicate from one bone-cell to another, thus transmitting the nourishment with which they are supplied by the blood-vessels throughout the substance of the bone. Figure 9, represents a longitudinal section of bone, highly magnified, showing the Haversian canals seen lengthwise, their connexion with each other, and the direction of the bone-cells. These figures are from *Hassall's Microscopic Anatomy.*


Pl. XVII
Fig. 1
Fig. 2
Fig. 3
Fig. 4
Fig. 5
Fig. 6
Fig. 7
A
B
Fig. 8
Fig. 9

405. At first, bones exist in a state of cartilage, and are gradually converted into bone by a deposition of phosphate and carbonate of lime.

406. The lime of the earthy portion of the bones is continually increasing till old age, while the animal portion is gradually diminishing. In children, the animal matter constitutes about one-half; in adults, one-fifth; and in old age, one-eighth of the whole composition.

407. In children, the bones are soft and flexible, and admirably adapted to sustain the numerous falls and accidents, to which they are liable, without injury. At this age, the bones are not easily broken, though they are bent and twisted from their natural form. Thus, infants are not unfrequently made "bow-legged," by efforts to bear their weight on their limbs before they have acquired the proper proportion of earthy matter to give them the requisite strength. If not encouraged by parental ambition, nature does not incline the young infant to make the effort to stand or walk until the period when the bones have become quite stiff and hard.

408. The bones do not arrive at their perfect state until about the twentieth year. Previous to this period, the form of the bones may be easily changed by improper habits. Indeed, some change may be effected in many of the bones at a much later period of life.

409. As the animal matter of the bones diminishes in old age, they become hard and brittle. In an aged person, a very slight slip or miss-step is sufficient to produce a fracture. Fortunately, the failure and decline of all the other powers compel this class of persons to move with so

In what state do bones exist at first? How are they converted into bone? Which portion of the bones continues to increase and which to diminish to old age? What proportion of the bones is animal matter in children?—in adults?—in old age? What is the condition of the bones in children? To what injury are the bones most liable at this age? How are infants made bow-legged? At what age do the bones arrive to perfection? What is the condition of the bones in old age? To what injury are the bones of the aged liable?

much care and caution, that the frailty of this part of the system is but seldom tested.

410. The earthy and animal portions of the bones can be easily separated from each other. To obtain the animal portion, we have only to soak the bone a few days in a diluted acid. When the earthy matter is then dissolved, the animal matter which is left becomes so soft and pliable, that a bone of sufficient length can easily be tied into a knot, as represented in *fig.* 2, Pl. XVII.

411. By exposing a bone to the action of a hot fire, the animal matter will be consumed, leaving it so brittle that it may be easily crumbled into fragments.

412. The bones of nearly all the higher animals present a great variety of form and structure, according to the position they occupy.

413. The principal bones of the extremities are long and cylindrical, and consist of a shaft and two extremities. The shaft of a long bone is dense and hard in structure, and hollow in the centre, forming a cylinder or a double arch—a form which, it is well known, receives the greatest amount of strength. The extremities of the long bones are broad and expanded, so as to present a large surface to articulate with adjoining bones, and their internal structure is cellular and cancellous, so as to secure as much bulk as possible in proportion to the quantity of matter. The internal structure of the long bones may be seen by a section of the thigh-bone, *fig.* 3, Pl. XVII.

414. The different bones of the body are united to each other by articulations and joints.

415. The different bones of the cranium and skull, which surround and protect the brain, are very firmly united by

How can we separate the animal from the earthy portion of the bones? How the earthy portion? What is said of the bones of the higher animals? What is the form of the principal bones of the extremities? Describe the shaft, and the extremities of a long bone. How are the different bones of the body united to each other? How are the different bones of the cranium united together?

PLATE XVIII.

ORGANS OF MOTION.—THE BONES.

FIGURE 1.——*Posterior View of the Humon Skeleton.*—THE HEAD.—*o*, The frontal-bone. *b*, *b*, The parietal bones. *c*, The left temporal-bone. *d*, The occipital-bone.

THE TRUNK.—1, 1, 1, Spinous processes of the vertebræ. *t*, *t*, *t*, Transverso processes of the vertebræ. 2, 2, Tho ribs. 3, The os innominatum, showing its three parts, viz: *a*, the ileum; *b*, the ischium; *c*, the os puhis. 4, The sacrum. 5, The coccyx.

THE SUPERIOR EXTREMITIES.—6, Tho scapula. 7, Acromion process of the scapula. 8, The clavicle. 9, Head of the humerus placed in tho glenoid cavity of the scapula. 10, Shaft of the humerus. 11, 12, Internal and external condyles of the humerus. 13, The olecranon process of the ulna, which articulates with the pulley-like surface at the lower end of the humerus, forming the elbow-joint. 14, Shaft of the ulna. 15, Shaft of tho radius. 16, Lower extremity of the radius, which articulates with the bones of the carpus. 17, Bones of the carpus. The first row consists of four bones, viz: *a*, the scaphoid-bone; *b*, the semi-lunar-bone; *c*, the cuneiform-bone; *d*, the pisiform-bone. The second row consists of four bones, viz: *e*, The trapezium. *f*, The trapezoid-bone. *g*, The os magnum. *h*, The unciform-bone.—18, 18, Bones of the metacarpus. 19, 19, 20, 20, 21, 21, First, second, and third ranges of finger bones.

THE INFERIOR EXTREMITIES.—22, Head of the femur, placed in the acetabulum or cotyloid cavity of the haunch-bone. 23, 24, Projections called trochanter major and minor, to which the muscles of the hip are attached. 25, Shaft of the femur. 26, 27, External and internal condyles of the femur. 28, Upper extremity of the tibia, which articulates with the femur. 29, Shaft of the tibia. 30, The internal malleolus, a projection of the tibia which forms the inner ankle. 31, The fibula. 32, External malleolus, a projection of the fibula which forms the outer ankle. 33, Bones of the tarsus. 34, Bones of tho metatarsus. 35, Bones of the toes. The ligameuts of the various joints are seen on the left side of this figure.

FIGURE 2.——*The Knee-joint.*—*A*, The knee-joint, with the patella removed. *a*, *o*, The condyles of the femur, covered with cartilage. *b*, *b*, The two semi-lunar cartilages, which form cup-shaped depressions for the reception of the condyles. *c*, The anterior crucial ligament which passes from the tibia to the femur. *B*, Section of the knee-joint, showing the reflections of the synovial membrane. *a*, The cancellous structure of the lower part of the femur. *b*, The tendon of the extensor muscle of the leg. *c*, The patella. *d*, The ligaments which attach the patella to the head of the tibia. *e*, The cancellous structure of the head of the tibia. *f*, The anterior ligament. *g*, The posterior ligament. The synovial membrane may be traced along the under surface of the patella and its ligaments, and then over the head of the tibia, over the posterior ligaments, and then over the lower part of the femur.

FIGURE 3.——*A Section of the Hip-joint.*—*a*, The head of the femur. *b*, *b*, The capsular ligament, embracing the cavity of the hip-bone and the head of the femur, and keeping both bones firmly together. *c*, A round ligament attached to the inside of the cavity and to the head of the femur.

FIGURE 4.——*The Bones of the foot, seen upon the upper surface.*—*a*, The os calcis, or heel-bone. *b*, The astragalus, which articulates with the lower end of the tibia. *c*, The cuboid-bone. *d*, The scaphoid-bone. *e*, *e*, *e*, Cuneiform bones.

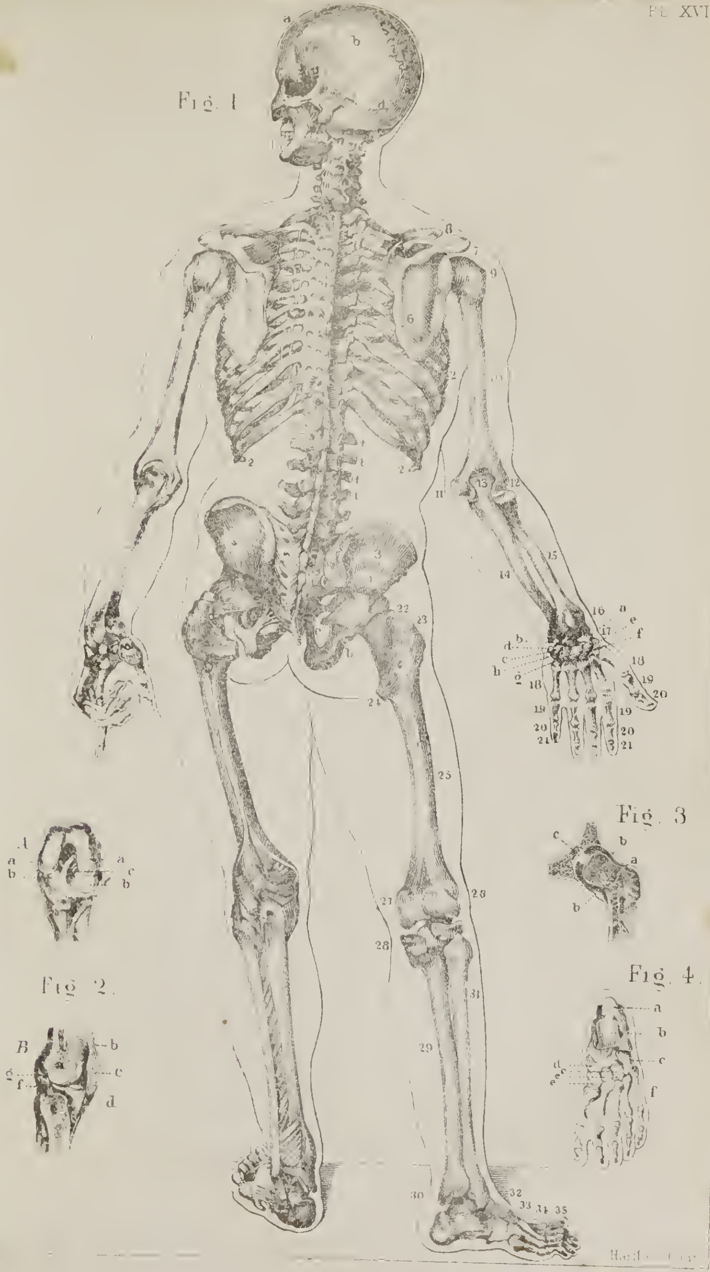


Fig. 1
Fig. 2.
Fig. 3
Fig. 4.

sutures (seams), which are formed by the interlocking of the ragged edges of one bone into corresponding notches in the adjoining one. These bones are thus so firmly united together in man at adult age, that it is difficult to separate them, except by breaking away some of the projecting parts.

416. The bones forming joints are firmly bound together by muscles and ligaments, and the end of each bone covered over by a thin layer of cartilage, which has a smooth glassy surface. Each joint is inclosed by a sac or capsule of serous membrane, which secretes a peculiar fluid, called *synovial fluid.* The office of the synovial fluid is to keep the joints constantly moist and supple.

417. After a severe injury to the joint, the synovial fluid is sometimes secreted in excess, causing "*dropsy of the joint.*"

418. The beautiful smoothness of the surfaces of the cartilages, and the manner in which the bones are bound together by ligaments and muscles, may be seen by examining the knee-joint of any of our domestic animals. In *fig.* 2, Pl. XVIII., is a section of the knee-joint in man, showing the reflection of its synovial membrane.

419. There are several kinds of joints in the body, the most important of which are the hinge-joint at the elbow and knee, and the ball-and-socket joint at the hip and shoulder.

420. In the hip-joint, the socket is much deeper than at the shoulder—an arrangement evidently designed to give greater security against dislocation in a part on which the weight of the whole trunk must press in walking, run-

How are the sutures formed? What is said of their firmness at adult age? How are the bones forming joints bound together? How is the end of each bone covered? How is each joint inclosed? What is the office of the synovial fluid? How is this fluid sometimes affected by an injury? How may the structure of a joint be seen? How many kinds of joints are there? What is said of the hip-joint? What circumstance seems designed to prevent dislocation at the hip-joint?

ning, leaping, &c. There is also a strong cord, fastened by one end to the top of the thigh-bone, and by the other to the socket in which it moves.

421. The skeleton of man is formed by the union of about two hundred and fifty bones, and is divided into head, trunk, and extremities.

422. The head includes the bones of the face and the cranium; the trunk includes all the bones immediately attached to the spine, except the head; the extremities embrace all the bones of the shoulders, arms, and legs, which are called *upper* and *lower* extremities in man, or the anterior and posterior extremities in quadrupeds.

423. The face is formed by the union of fourteen bones, which serve for the lodgment and protection of the organs of sight, smell, and taste.

424. The cranium or skull is a bony case, of an oval form, occupying the upper and back part of the head, and serving for the protection of the brain, which is lodged in its cavity. Its walls are made up of eight bones, which are firmly united to each other in such a manner that every part is admirably adapted to resist external force.

425. The cranium is constructed on the principle of the arch, the bones at the base of the skull overlapping those above so firmly, that a separation is rarely, if ever, effected during life, and only with great difficulty after death.

426. The spinal column or back-bone, as it is commonly called, consists in man of thirty-three different bones, called *vertebræ*, which are divided as follows, in man: seven cervical vertebræ, (vertebræ of the neck,) twelve dorsal vertebræ, (vertebræ of the back,) five lumbar vertebræ, (vertebræ of the loins,) five sacral vertebræ, four coccygeal

Of how many bones is the skeleton of man formed? How is it divided? What bones are included in the head?—the trunk?—the extremities? Of how many bones is the face formed? Describe the cranium. Its walls are made up of how many bones? On what principle is the cranium constructed? How is a separation of the bones prevented? Of how many bones does the spinal column consist? How are they divided?

vertebræ. All these vertebræ are separate at the time of birth, but the five sacral vertebræ are soon after united into one piece—the sacrum—and the four coccygeal vertebræ are also united into one piece, the coccyx.

427. The number of the cervical vertebræ is the same in all the mammalia. Birds have a much larger number: the swan, which is remarkable for the gracefulness and beauty of its neck, has twenty-three vertebræ, the crane has seventeen, and the swallow thirteen.

428. The number of the dorsal vertebræ is the same as the number of the ribs on each side. In man, there are twelve dorsal vertebræ, in the lion thirteen, and in the elephant twenty.

429. The vertebræ are perforated by an aperture, so that when they are all united, they form a continuous tube or canal for the lodgment of the spinal cord.

430. By the division of the spinal column into so large a number of separate bones, very great freedom of motion is allowed, with only a slight bend at any particular point.

431. Each vertebræ consists of a body, which is situated in front of the spinal canal in man, and below it in quadrupeds; and of seven processes or projections, which serve to form the spinal canal, and unite the vertebræ to each other by affording attachments for the muscles.

432. In man and the other mammalia, the two surfaces of the body of the vertebræ are nearly flat, and are separated from each other by a disc of fibro-cartilage.

433. In reptiles and fishes, a different plan is adopted. In serpents, one surface of each vertebra is concave and the other convex, and thus the convex surface of each

What change takes place with the five sacral vertebræ? What is said of the number of the cervical vertebræ in the mammalia?—in birds? How many cervical vertebræ has the crane and the swallow? What do the vertebræ form when united together? What is gained by the division of the spinal column into so many separate pieces? Of what does each vertebræ consist? What is the form of the two surfaces of the body of the vertebræ? What is the form in fishes and reptiles? What kind of a joint do they form?

vertebra fits into the concave surface of the next, in such a manner that the whole spine becomes a series of ball-and-socket joints—an arrangement which is remarkably adapted to the peculiar movements of those animals.

434. In fishes, both surfaces are concave, and between each vertebra there is interposed a bag, containing fluid, and having two convex surfaces, over which those of the vertebræ can freely play. Very great freedom of motion is thus acquired, though the strength is proportionably diminished. But great strength is not required by animals whose bodies are supported by a medium which is nearly of the same density with themselves.

435. The extreme flexibility of fishes enables them to propel their bodies by the movements of the tail and hinder parts from side to side, their fins being used principally for influencing their direction.

436. Man is the only animal whose spine seems adapted to the erect attitude. Its form has some resemblance to the letter S, being a double curve, and it thus forms a kind of spring that is admirably adapted to diminish the shock produced by a sudden jar, as in the act of jumping upon the feet from a height. The bodies of the vertebræ are also broader, in proportion to their size, than in other animals, while the spinous processes, which form the ridge along the back, are considerably shorter In quadrupeds which maintain a horizontal position of the spinal column, the spinal processes are very long, for the attachments of muscles to support the head. In *figs.* 9 and 10, Pl. XIX., may be seen a comparative view of the vertebræ in the lion and ox.

437. The ribs, which are twelve on each side in man, are attached by one extremity to the transverse processes

How are the two surfaces separated in fishes? How do fishes propel their bodies? For what purpose are fins used? What attitude is peculiar to man? What is the form of the spine in man? What advantage is obtained by this form? How do the vertebræ in man differ from those of all other animals? What is said of the spinal processes in quadrupeds? How many ribs are there in man? What are the attachments of the ribs?

PLATE XIX.

THE EXTREMITIES.

Figure 1.——*Anterior Extremity of Man.*—*a*, Scapula, or shoulder blade. *b*, The humerus, or principal bone of the arm. *c*, The radius. *d*, The ulna. *e*, The carpus, or wrist. *f*, The metacarpus, or palm. *g*, The phalanges, or fingers.

In figures 2, 3, 4, 5, 6, 7, and 8, the corresponding bones are indicated by the same letters as in figure 1.

Figure 2.——*Anterior Extremity of the Deer.*

Figure 3.——*Anterior Extremity of the Lion.*

Figure 4.——*Anterior Extremity of the Whale.*

Figure 5.——*Anterior Extremity of the Bat.*

Figure 6.——*Anterior Extremity of the Bird.*

Figure 7.——*Anterior Extremity of the Sloth.*

Figure 8.——*Anterior Extremity of the Monkey.*

Figure 9.——*Skeleton of the Lion.*—*a*, The skull. *b*, The cervical vertebræ. *c*, The dorsal vertebræ. *d*, The lumbar vertebræ. *e*, The sacrum. *f*, The caudal vertebræ, which compose the tail. *g*, The ribs. *h*, The scapula. *i*, The humerus. *j*, The fore-arm.—In this part, corresponding to the fore-arm of man, the two bones are united into a single one. *k*, Bones of the wrist, or carpus. *l*, Bones of the metacarpus, or hand. *m*, The phalanges. *n*, The femur, or thigh-bone, united to the bones of the pelvis. *o*, The patella, or knee-pan. *p*, The tibia; the two bones of the leg being united into one. *q*, Bones of the tarsus, or ankle. *r*, Bones of the foot and toes.—In the lion, the bones of the arm are stout and long, and the fingers short and compact, collectively combining freedom of motion and strength, and admirably adapting this class of animals to the sudden springs with which they pounce upon their prey.

Figure 10.——*Head and Shoulders of an Ox.*—*a*, The skull. *b*, The cervical vertebræ. *c*, The dorsal vetebræ, which are very long, for the attachment of the muscles which support the neck and head. *d*, The scapula, or shoulder-blade.

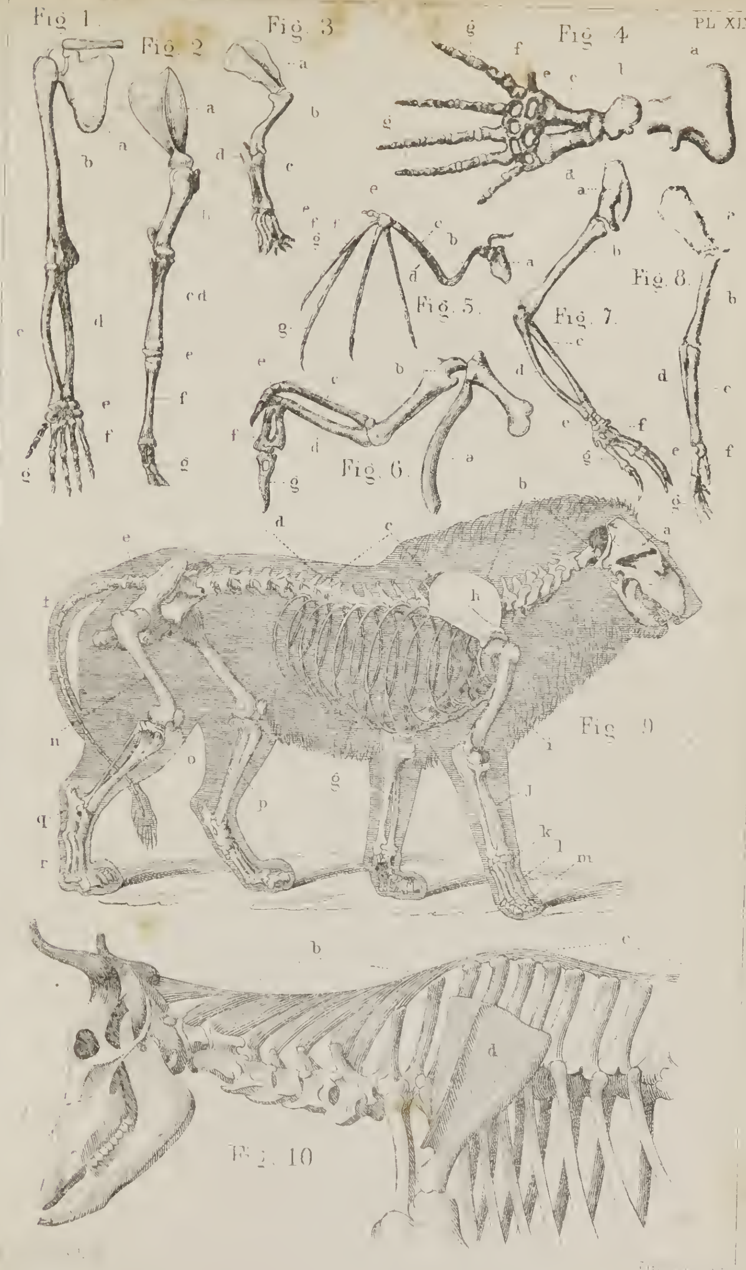

PL. XIX
Fig. 1.
Fig. 2.
Fig. 3.
Fig. 4.
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Fig. 8.
Fig. 9.
Fig. 10.

of the dorsal vertebræ, and by the other to cartilages which are continuations of the ribs. The cartilages of the first seven, or true ribs, (*aa*, *fig.* 1, Pl. XVII.,) are united to the sternum or breast-bone; the cartilages of the five lower ribs (*bb*, *fig.* 1, Pl. XVII.) are not directly connected with the sternum, and are hence called *false ribs*.

438. The *sternum*, or breast-bone, (*fig.* 1, Pl. XVII.) is flat in man, but in those animals which have need of great strength in the upper limbs it is increased in breadth, and furnished with a projecting keel or ridge for the attachment of powerful muscles. In the turtle tribe, it is so far extended as to afford a complete protection to the under side of the animal.

439. The extremities, which have been regarded as appendages to the trunk, are four in number in all the vertebrated animals, and are constructed on the same general plan, though they are widely different in general appearance. The fin of a fish, the wing of a bird, the leg of a lion or a deer, and the arm of man, are evidently adapted to very different uses, and are apparently destitute of any very striking resemblance to each other; yet, when those same limbs are stripped of the skin and muscles, they will be found to possess the same essential parts, slightly modified, according to their several uses.

440. One of the superior extremities of man, and one of the anterior extremities of a deer, a lion, a whale, a bat, and a bird, are represented by the same letters in *figs.* 1, 2, 3, 4, 5, and 6, Pl. XIX.

441. The *scapula*, or shoulder-blade, is a large flat bone, attached to the back part of the trunk by muscles. In

How many of the cartilages are attached directly to the breast-bone? What are the five lower ribs called? What is the form of the breast-bone in man?—in those animals which have need of great strength in the upper limbs? What is said of it in the turtle? How many extremities are there in all the vertebrated animals? What is said of their construction? What illustrations are given? Describe the scapula or shoulder-blade. How is it attached to the trunk? What advantages are derived from this kind of attachment?

animals which walk on all-fours, this kind of attachment secures much greater elasticity of movement, and also diminishes the force of the shock in the acts of leaping or running. In man, it gives greater freedom of motion to the arm.

442. The *clavicle*, or collar-bone, is attached at one extremity to the shoulder-blade, and at the other to the sternum or breast-bone. It acts as a brace to separate the shoulders, and it is accordingly strongest in those animals, the action of whose superior extremities tend to draw them together; while it is comparatively weak, or altogether deficient, in those animals, the action of whose limbs naturally tends to keep them asunder. Thus, in birds, there is not only a strong clavicle, but a second bone also, tending to keep the shoulders apart. In the lion, deer, &c., it is entirely wanting.

443. The arm is supported by a single long and cylindrical bone, *c*, the humerus. In the fore-arm, there are two long bones, the radius and ulna (*d*, *e*), which lie parallel to each other. The radius is on the outer or thumb side of the fore-arm, and the ulna on the inside. The radius and ulna are connected with one another by ligaments at their extremities, and by a strong fibrous membrane, that passes between their adjacent edges along their entire length. Those bones rotate freely on each other, in such a manner that either the palm or back of the hand may be turned. In most quadrupeds, the radius and ulna are so firmly united together as to be incapable of rotation.

444. The hand is anatomically divided into three portions--the *carpus*, *metacarpus*, and *phalanges*. The carpus,

What are the attachments of the clavicle? What is the use of this bone? In what animals is it strongest? In what animals weakest? How is it in birds?—in the lion, deer, &c.? How is the arm supported? How many bones are there in the fore-arm, and what are they called? On which side is the radius?—the ulna? How are the radius and ulna connected to each other? How do these bones rotate on each other? In what condition are the radius and ulna in most quadrupeds? How is the hand anatomically divided? Describe the carpus—the metacarpus—the phalanges.

which is nearest the wrist-joint, is composed of eight small bones, which are firmly united to each other by ligaments —the metacarpus, which consists of five long cylindrical bones, resembling the bones of the fingers so much, that in the skeleton they might be easily mistaken for their joints. The fingers are formed by a series of small bones, called phalanges, of which there are only two in the thumb, and three in each of the fingers.

445. As the foot and ankle, which correspond to the wrist and hand in man, are designed for solidity in quadrupeds, we find in different parts that there is only one solid piece for two, three, or more bones in corresponding parts in man, though those solid pieces are found originally to have been several distinct bones that have afterwards united. Thus, in the ruminating animals, as the deer (*fig.* 59), the number of phalanges is reduced to two, and in the horse (*fig.* 60), there is but one, which is enveloped by the hoof.

Fig. 59.

Fig. 60.

446. The structure of the lower extremities has a very great analogy to that of the upper, the principal differences being such as are necessary to make the lower extremities more solid, and better adapted to serve as organs of locomotion, instead of organs of prehension.

447. The lower extremities are connected with the spine by a bony case or basin, called the *pelvis*. The thigh,

How many phalanges are there in the thumb?—in the fingers? How are the foot and ankle in quadrupeds made more solid than the wrist and hand in man? Are these parts found solid originally? How many phalanges are there in the deer?—in the horse? How do the upper and lower extremities differ from each other? How are the lower extremities connected with the spine? How is the thigh supported?

like the arm, is supported by a single long cylindrical bone, called the *femur*, which is bent at the upper extremity at an angle, and its rounded head separated from the main bone by a narrow portion, called its neck. The lower end of the thigh-bone spreads into long condyles, on which the large bone of the leg moves backward and forward.

448. The leg has two bones, but they do not possess the power of rotating on each other like the fore-arm. The main bone, or *tibia*, is much larger than the *fibula*, which is a long slender bone, running parallel with the tibia, and apparently serving no other purpose than to give attachment to the muscles. The upper end of the tibia is broad, and has two shallow depressions, in which the condyles of the femur or thigh-bone are received.

449. In front of the knee-joint is a small bone, called the *patella*, which serves the double purpose of protecting the joint and changing the direction of the tendon which comes down from the thigh.

450. The foot is composed, like the hand, of three distinct portions—the *tarsus*, the *metatarsus*, and the *phalanges* or toes. There are seven bones in the tarsus, all of which are larger than those of the carpus. The metatarsus is composed of five long bones in man. The toes, like the fingers, have three phalanges, each, except the great-toe, which has only two. The tarsus and metatarsus form a kind of arch on the inside of the foot, which serves to lodge and protect the vessels and nerves that descend from the legs to the toes. This arch also serves to deaden the shock that would be experienced every time the foot was put to the ground; for by the elasticity of the ligaments which bind these bones together, a kind of spring is

What is the form of the upper extremity?—of the lower extremity? How many bones form the leg? What is their comparative size? Describe the tibia. What bone in front of the knee-joint? What is its use? Of how many portions is the foot composed, and what are they called? How many bones in the tarsus?—the metatarsus? How many phalanges are there in the toes? What do the tarsus and metatarsus form? What advantages are derived from this form of the foot?

PLATE XX.

ORGANS OF MOTION.—THE BONES.

FIGURE 1.——*Skeleton of the Camel.*—The black ground in this and the two following figures shows the outline of the form when clothed with flesh. *a*, The skull. *b*, The cervical vertebræ. *c*, The dorsal vertebræ.—The spinous processes of these vertebræ are much longer and larger than those of man, for the purpose of giving attachment to the strong muscles and ligaments by which the heavy neck and head are supported. *d*, The lumbar vertebræ. *e*, The sacrum. *f*, The caudal vertebræ, which compose the tail. *g*, The ribs. *h*, The scapula. *i*, The humerus. *j*, The fore-arm.—In this part, corresponding to the fore-arm of man, the two bones are united into a single one. *k*, Bones of the wrist or carpus. *l*, Bones of the metacarpus or hand. *m*, The phalanges. *n*, The femur, or thigh-bone, united to the bones of the pelvis. *o*, The patella, or knee-pan. *p*, The tibia; the two bones of the leg being united into one. *q*, Bones of the tarsus or ankle. *r*, Bones of the foot and toes.—In animals which do not possess fingers, the bones of the fore-arm, wrist, and hand are always few in number. Thus, in the camel, and in all herbivorous quadrupeds, the fore-arm has only one bone; the wrist, about four; the hand, only one, with sometimes the rudiment of another; while some species have two toes, and others only a single one.

FIGURE 2.——*Skeleton of the Vulture.*—*vc*, Cervical vertebræ, fifteen in number. *b*, Dorsal and lumbar vertebræ. *vs*, The sacrum. *vq*, Vertebræ of the tail. *st*, The breast-bone, or sternum. *cl*, The clavicle. *h*, The humerus. *o*, The two bones of the fore-arm. *ca*, Bones of the wrist, imperfectly developed. *ph*, Bones of the hand and fingers. *f*, The thigh-bone. *t*, The two bones of the leg. *ta*, The shank or ankle bones.

FIGURE 3.——*Skeleton of Turtle.*—*a*, Cervical vertebræ. *b*, Scapula. *c*, Clavicle. *d*, Coracoid-bone. *e*, Dorsal vertebræ. *f*, Ribs incorporated with the dermal plates which form the shell. *g*, Marginal plates. *h*, Pubic bones. *i*, Femur. *k*, Tibia. *l*, Fibula.

FIGURE 4.——*Skeleton of the Perch.*—*a*, *b*, First and second dorsal fins. *c*, The caudal or tail-fin. *d*, The anal-fin. *e*, One of the ventral fins, which correspond to the legs. *f*, One of the pectoral fins, which are analogous to the arms. The spinous processes of the vertebræ are long, and are connected with another set of bones, by which they are continued upward, so as to form the frame-work of the fins which arise from the back. The whole number of vertebræ is forty-two, of which twenty-one are dorsal and twenty-one caudal or coccygeal. The number of pairs of ribs is the same as that of the dorsal vertebræ.

Fig. 1.

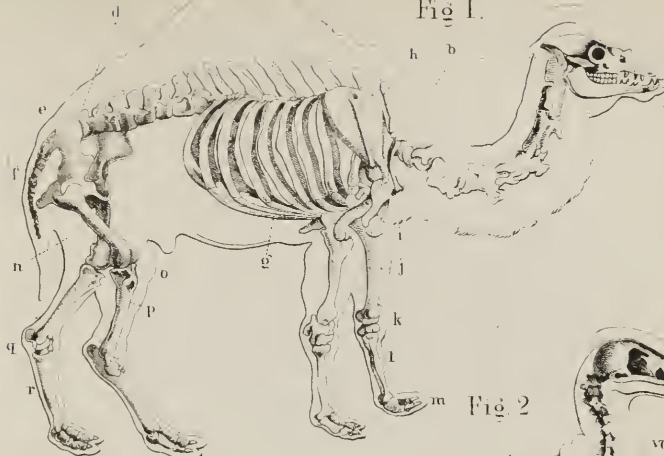


Fig. 2

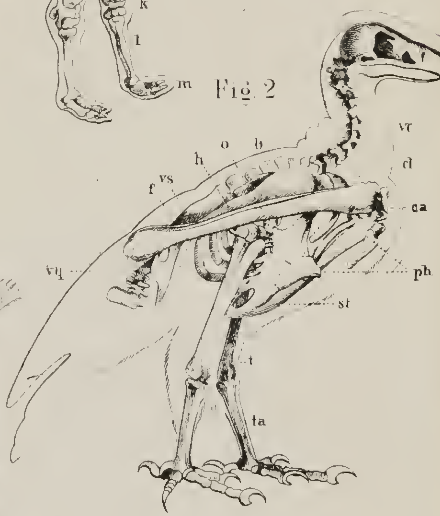
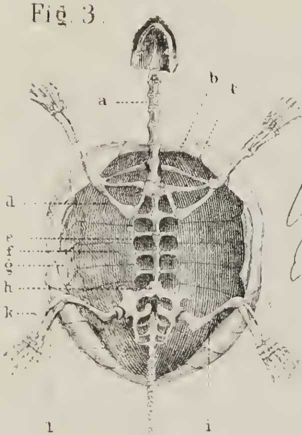


Fig. 3.



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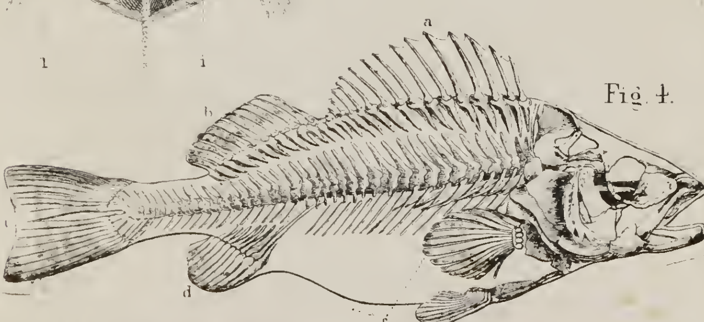

formed, which yields for a moment to the shock, and then recovers itself.

451. In animals which walk on all-fours, the difference of direction in which the bones of the legs are connected with the spine, prevents a jar from extending to the body. In those animals which obtain their food by sudden and extensive leaps—such as the cat, tiger, and lion—there is an arrangement of the bones admirably adapted to diminish the shock produced by a sudden descent of the body upon the ground.

THE MUSCLES.

452. The muscles are the moving power by which the parts of the skeleton are set in motion.

453. Each muscle, if examined carefully, is found to be made of a number of bundles of fibres, and each fibre is formed of numerous smaller fibres or fibrils. The primitive fibrils are only about $\frac{1}{10,000}$th of an inch in diameter. Each fibre, which extends from one end of the muscle to the other, is supplied with one or more loops of nervous filaments. Through the influence of the nervous system, the muscular tissue is capable of being excited to sudden and forcible contraction. In contracting, the two ends of a muscle approach each other, and swell out in the middle to a corresponding degree. Thus, the whole muscle, when shortened by the drawing together of its two ends, is greatly enlarged in diameter, especially towards the middle.

454. The energy of muscular contraction depends, in a great degree, upon the power of the stimulus which is transmitted to the muscles from the brain.

In animals which walk on all-fours, how is a jar prevented from extending to the body? How are the parts of the skeleton set in motion? Of what is each muscle made up? What is the size of the primitive fibrils? With what is each fibre supplied? How is the muscular tissue excited to contraction? What change takes place in a muscle when it contracts? When is the muscle enlarged most in diameter? Upon what does the energy of the muscular contraction depend?

455. This is frequently observed in instances of great nervous excitement, as when a person is under the influence of violent passion or insanity. A delicate female is thus often a match for three or four strong men, and can even break cords and bands that would hold the most powerful man.

456. In the production of animal motion, the bones not only serve as points of attachment for the muscles, but they constitute a series of levers for the application of muscular force.

457. Most of the muscles act on the bones at great mechanical disadvantage, though it is a law in mechanics that what is lost in power is gained in time. Thus, in *fig.* 76, the muscle (*a*) which arises from the top of the

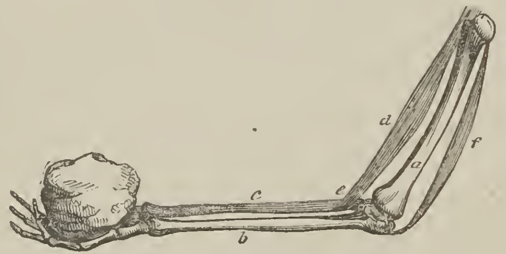

Fig. 61.

shoulder, and is inserted at *e*, a short distance from the elbow, acts at a great mechanical loss of power in raising the fore-arm, but its contraction to a very slight extent will raise the hand through a considerable space. Thus, since the muscle is inserted about one-sixth of the distance from the elbow to the wrist, it will require a force of contraction in the muscle equal to six pounds to raise one pound at the wrist, while its contraction of one inch will

In what cases of great nervous excitement is this frequently observed? What example is given? What other purpose do the bones serve besides affording attachment for the muscles? How do most of the muscles act on the bones? What law of mechanics in regard to this? Explain Figure 65 What force in the muscle will be required to raise one pound at the wrist?

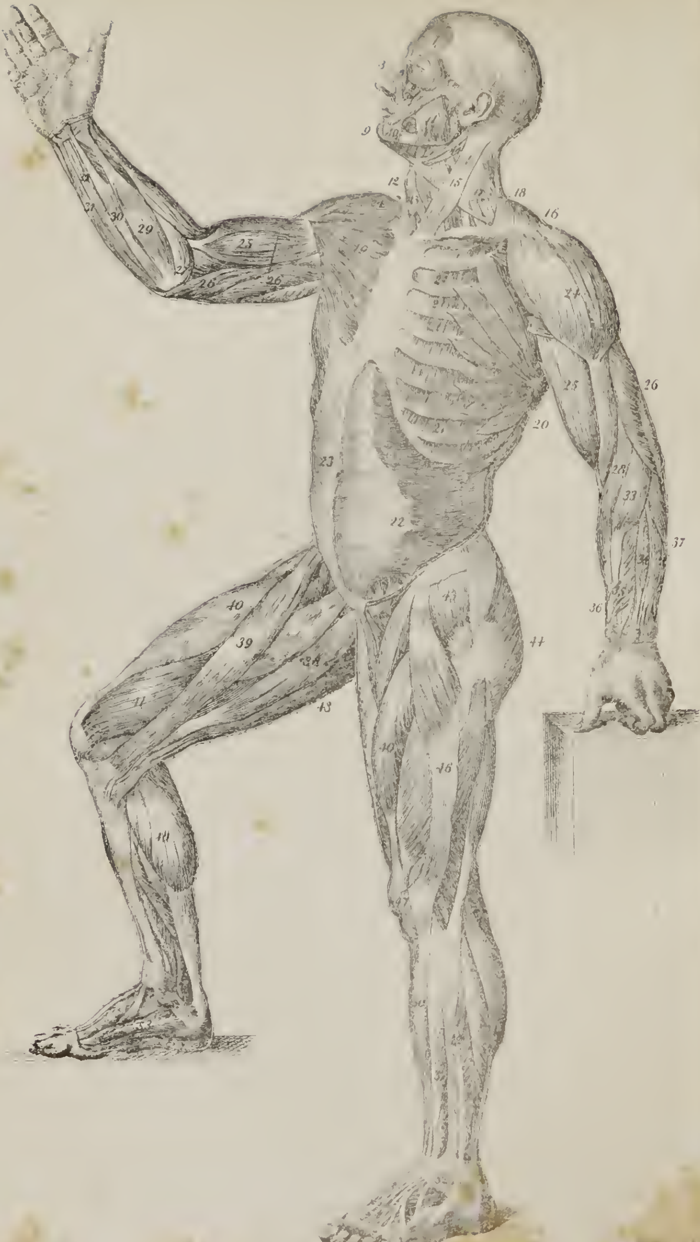
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PLATE XXI.

ORGANS OF MOTION.—THE MUSCLES.

LATERAL VIEW OF THE PRINCIPAL MUSCLES OF THE HUMAN BODY.

Muscles of the Head and Neck.—1, The occipito-frontalis muscle, which elevates the eyebrows, and wrinkles the forehead, expressing astonishment or attention. 2, The orbicularis palpebrarum, which closes the eyelids. 3, Triangularis nasi, which compresses the nostrils. 4, The levator labii superioris, which raises the upper lip and expands the nostrils, expressing disdain. 5, Zygomaticus major. 6, Zygomaticus minor: These muscles raise the upper lip and draw it outward. 7, Orbicularis oris.—Only half of this muscle is seen on the plate. It extends completely around the mouth, which its action is to close. It also assists the lips in whistling, blowing and sucking. 8, The buccinator, or trumpeter's muscle.—It elongates the mouth transversely, and is greatly used in blowing wind-instruments. 9, Depressor labii inferioris, which draws down the under lip, expressing chagrin, disgust. 10, Depressor anguli oris, which depresses the angle of the lips. 11, The masseter.—This powerful muscle is the essential agent in mastication. It raises the lower-jaw, and brings its teeth strongly against those of the upper-jaw. 12, Omo-hyoideus, extending from the edge of the scapula to the hyoid-bone, which it depresses. 13, Sterno-hyoideus, a depressor of the larynx. 14, The digastricus, an elevator of the larynx and a depressor of the lower jaw. 15, The Sterno-cleido-mastoideus, extending from the temporal-bone to the sternum and clavicle.—When one of these contracts, it draws the head to its own side; when both contract, the head is carried forward. 16, The upper portion of the trapezius.—(*See* PLATE XXII.) 17, 18, Scalenus posticus and anticus, which elevate the ribs and assist in respiration.

Muscles of the Trunk.—19, The pectoralis major, a large muscle, attached to the clavicle, sternum and ribs, and to the humerus. It draws forward the shoulder, and also elevates the ribs, acting as a muscle of inspiration. 20, The serratus magnus, a powerful muscle, lying beneath the pectoral muscle.—It is divided into slips or digitations, which extend from the ribs to the scapula. It is a muscle of inspiration, the contraction of its slips tending to separate the ribs and thus dilate the chest. 21, 21, &c. External intercostal muscles, which elevate the ribs. 22, The transversalis abdominis. This muscle draws the front of the abdomen inward, thereby pushing up its contents against the diaphragm, in the act of expiration. 23, Rectus abdominis, which draws the chest forward toward the pelvis, and assists in straightening the trunk when it has been thrown backward.

Muscles of the Superior Extremities.—24, The deltoid muscle. This thick and powerful muscle is attached to the scapula and to the humerus. Ordinarily it elevates the arm; but when the body is raised by the arms, as in climbing, it draws up the trunk. 25, The biceps brachialis.—This is the large muscle whose projection is felt in front of the arm. It is a flexor of the fore-arm. 26, 26, 26, Portions of the triceps brachialis.—(*See* PL. XXII). 27, The pronator teres.—This muscle, being attached to the radius, and having its fixed insertion on the humerus, rolls the radius inward, and thus turns the palm of the hand downward. 28, The supinator longus.—This muscle acts as an antagonist to the last, and

turns the hand upward. 29, The flexor carpi radialis. 30, The palmaris longus. 31 Flexor carpi ulnaris.—These three muscles are flexors of the wrist upon the fore-arm. Their white and slender tendons are attached to the carpal and metacarpal bones. 32, Tendons of the flexor sublimis digitorum, which bend the second range of the finger-bones upon the first. 33, Extensor carpi radialis longior.—This muscle extends the wrist upon the fore-arm. 34, Extensor communis digitorum.—(*See* Pl. XXII.) 35, Lower portion of the abductor pollicis longus. 36, Lower portion of the extensor pollicis brevis.—These two muscles draw the thumb outward, and bend it on the carpus. 37, Extensor carpi ulnaris.—(*See* Pl. XXII.)

Muscles of the Inferior Extremities.—38, The rectus internus.—This muscle is a flexor of the leg. 39, The sartorius or tailor's muscle, the longest muscle in the body.—By its action the legs are bent inward, so as to cross each other. 40, The rectus femoris. 41, The vastus internus. 42, The vastus externus.—These three muscles extend the leg upon the thigh. 43, Portion of the adductor magnus.—This muscle draws backward the thigh at the hip. 44, A portion of the gluteus maximus.—(*See* Pl. XXII.) 45, The gluteus medius. 46, A tendinous expansion called the fascia-lata, forming part of the femoral aponeurosis. 47, The tendon of the vastus femoris, which contains the patella. 48, The triceps suræ, or extensor of the foot, composed of three large fasciculi.—(*See* Pl. XXII.) 49, The peroneus longus; its tendon passes behind and beneath the outer ankle, in a pulley-like groove, and is inserted into the first metatarsal-bone. By its contraction, this muscle extends and rotates the foot. 50, The tibialis anticus.—This muscle is attached by its tendon to a bone of the instep, and bends the foot upward. 51, The extensor digitorum communis.—Its four tendons are seen proceeding under the annular ligament of the tarsus, and diverging to the four smaller toes. This muscle extends the joints of the toes, and bends the foot upon the leg. 52, Annular ligament of the tarsus. 53, Adductor pollicis pedis.—(*See* Pl. XXII.)

move the wrist through six inches of space. In the same manner the muscle *m* (*fig.* 62), which lies on the back of the arm, and contracts in the direction of the letter *n*, acts with a similar disadvantage in regard to power, though it has a corresponding advantage in point of time.

Fig. 62.

458. Under ordinary circumstances, the energy of muscular action depends on the condition of the muscles themselves. Those muscles which are firm, plump, and high-colored, act with greater force than those which are pale and flabby. In the sedentary and inactive, the muscles are smaller in size and less vigorous than in those whose habits are more active. Within certain limits, the muscles increase, both in size and power, by use. In the smith, who makes constant use of his arms, the muscles are proverbially large and powerful; in the pedestrian, the muscles of the legs become developed.

459. The free exercise of the muscles not only increases the general strength, but greatly improves the vigor and health of all the physical powers.

460. The energy of muscular contraction appears to be greater in insects, in proportion to their size, than in any other animals. Thus, a flea will leap sixty times its own length, and move as many times its own weight. The same muscular power, in a man of six feet, would enable him to leap a distance of over three hundred feet, and to

If this muscle contracts one inch, through what space will it move the wrist? Under ordinary circumstances, upon what does the energy of muscular contraction depend? What kind of muscles act with greatest energy? What is said of the muscles in the sedentary and inactive? How are the muscles affected by use? What is said of the arms of the smith, and the legs of the pedestrian? What is said of the influence of exercise on the muscles, and on the health of all the powers? In what animals is the energy of muscular contraction greatest in proportion to size? How far will a flea leap? How far would the same muscular power in man enable him to leap? How much would it enable him to lift?

lift a weight of over ten thousand pounds. A species of beetle can support a weight equal to at least five hundred times that of its own body; and another, by the power of its jaws, has been known to gnaw a hole of an inch in diameter in the side of an iron canister in which it had been confined. The rapidity of the movements in insects is also so great, that the vibrations of the wings in some species have been calculated at several hundred, and, in some of the smaller insects, at several thousand in a second of time.

461. The various kinds of progression in different animals are called *swimming*, *crawling*, *flying*, *walking*, *running*, *jumping*, &c.

462. In fishes, the body is propelled through the water by the tail, on the same principle as a boat in impelled by sculling. The tail being vertical, in most cases its stroke is horizontal, and the body is propelled forward by the resistance of the water to its broad expansion, as it strikes from

Fig. 63.—TAIL-FIN OF WHALE.

side to side, by the alternate contraction of the muscles which extend from the long process of the vertebræ to the tail. In the whale, the tail (*fig.* 63) is expanded hori-

What is said of some species of beetle? What is said of the movements of insects? What are the various kinds of progression in animals called? How is the body in fishes propelled through the water? How is the stroke made against the water in most cases? What propels the fish? How is the tail expanded in the whale, and how is its stroke made? What is said of the structure of the tail?—of the power of the whale?

zontally, so that its stroke is vertical. The texture of the tail is such, that it is insensible to pain, and it is so tough that it is rarely torn or injured. The whale is therefore capable of inflicting a tremendous blow without any pain to itself, and of cutting a strong boat asunder, or of driving it with the swiftness of an arrow to the depth of many fathoms.

463. The fins of fishes are used principally to give direction to the body as it is propelled through the water.

464. In serpents, progression is effected by undulations of the spine, or by bringing the two extremities of the body near together, and then, the tail being fixed, the head is projected forward the length of the body: again the tail is brought forward, and the same process repeated. Sometimes, instead of this alternate contracting, the whole body is brought into a spiral coil, and by the contraction of all the muscles on one side, and then by a sudden contraction of the muscles of the opposite side, the whole body is propelled, as by the unwinding of a powerful spring, with an impulse which raises it to some height from the ground.

465. Flying has some resemblance to swimming, both being executed in a fluid medium, which, to a certain extent, buoys up the body and offers resistance to its progress. Water, however, affords more support to the body and a greater resistance to the propelling organs. Birds are especially adapted to flying by their formation. Their bones excel those of all other animals in combining strength and lightness. All the long bones are hollow cylinders filled with air. The breast-bone, which resembles in form the keel of a ship, presents a very large surface for the attachment of the muscles, and it is also connected very

For what are the fins of fishes principally used? How is progression effected in serpents? What other mode of progression is there in some serpents? What does flying resemble? How are birds adapted to flying? In what respect do the bones of birds excel all other animals? What are the long bones? What does the breast-bone resemble?

firmly by the ribs to the vertebræ of the back. The whole bony apparatus of the body is thus very strongly knit together, and yet the entire skeleton is exceedingly light—the body being suspended in the air by the resistance it affords to the wings. The muscles which are attached to the breast-bone are much larger than in other animals; while the muscles on the back, that raise the wings, are correspondingly smaller. The greatest power of the wings is consequently in the downward direction. In the effort to fly, the wings are expanded, brought down with considerable force, and then brought up to the body, being raised again in such a form as to offer the least possible resistance to the air.

466. In many birds the rapidity of flight is very great, much greater than by any other mode of progression. The Eider-duck is said to fly ninety miles an hour, and some species of hawk one hundred and fifty.

467. Walking is produced by the alternate contraction and extension of the limbs. In man, one foot is placed in front upon the ground while the other is extended or carried backward, and its length increased, carrying forward the whole body. In quadrupeds, two feet are placed on the ground at once.

468. In running, the body momentarily quits its support on the ground at intervals, the foot in advance not being planted on the ground at the time, the hinder one quits it. In this action, the ostrich probably surpasses all other animals, as it is said to outstrip the swiftest greyhound at its greatest speed.

469. In trotting, the fore-foot of one side and the hind-

What is gained by this peculiar form? How is the bony apparatus united together? What is said of the skeleton? How is the body suspended in the air? What is said of the muscles which are attached to the breast-bone?—to the back? In what direction is the greatest power of the wings? Describe the movement of the wings in the effort to fly? What is said of the rapidity of flight in birds? What examples? How is walking produced? How is it produced in man?—in quadrupeds? Describe running. What animal surpasses all others in running? Describe trotting.

PLATE XXII.

ORGANS OF MOTION.—THE MUSCLES.

POSTERIOR VIEW OF THE MUSCLES.

The right side of the figure displays the outer or superficial layer of muscles. On the left side, they are represented clothed with their fasciæ or aponeuroses, which form a tendinous membrane.

Muscles of the Head and Neck.—1, The occipitalis.—This muscle draws the scalp backward and downward, giving the expressions of joy or surprise. 2, Muscles of the ear. 3, The masseter. 4, The sterno-cleido-mastoideus. 5, The splenius.—When the two splenii act together, they draw the head backward, elevating the chin; when one acts, it bends the head and neck to one side.

Muscles of the Trunk.—6, The trapezius.—This muscle is attached to the spinous processes of the dorsal vertebræ and to the scapula. It carries the shoulder backward. 7, The latissimus dorsi.—*a*, *a*, Its tendinous or aponeurotic portion.—This broad muscle draws down the arm, or, if the arm be fixed, it draws the trunk towards the shoulder. 8, Part of the obliquus externus.—This muscle compresses and raises up the contents of the abdomen.

Muscles of the Superior Extremities.—9, Posterior portion of the deltoid muscle. 10, The infra-spinatus.—This muscle turns the shoulder outward, and assists in keeping the head of the humerus in its socket. 11, 11, 11, The three portions of the triceps extensor cubiti.—This muscle is fixed by its tendon to the olecranon process of the ulna, and by its contraction it extends the fore-arm. 12, The extensor communis digitorum.—Its four tendons pass under the annular ligament, and go to the four fingers; so that it becomes an extensor of the whole hand, as well as of each of the phalanges. 13, The extensor proprius of the little-finger.—By means of this slender muscle, the little-finger can be separately extended. 14, The extensor carpi ulnaris.—This muscle extends the hand on the wrist. 15, Flexor carpi ulnaris. 16, Tendon of the long extensor of the thumb. *l*, Annular ligament of the carpus.

Muscles of the Inferior Extremities.—17, The gluteus maximus.—This large, thick muscle is of greater volume than any other in the body, and is the principal agent in preserving its equilibrium. It extends from the iliac bones to the femur, and acts as an extensor of the thigh. 18, The biceps femoris.—This strong muscle, extending from the pelvis to the tibia, bends the leg, and also extends the pelvis upon the leg, keeping it erect. 19, The semi-tendinosus.—This muscle bends the leg upon the thigh, turns the point of the foot downward and inward, and keeps the pelvis erect when standing. 20, The vastus externus. 21, 21, The triceps suræ, consisting of three portions—the gastrocnemii, *a*, *b*, and the soleus, *c*; it terminates in the strong tendon of Achilles, *d*. It forms the extensor muscle of the foot.

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foot of the other one are raised and carried forward together; and when these are set down, the other fore and hind foot are raised and advanced.

470. In leaping, the body is projected into the air by the sudden extension of the joints, especially those of the hinder parts of the body which have been previously bent, and having traversed a greater or less distance, the body comes again to the ground. The hare, rabbit, squirrel, kangaroo, &c., are especially adapted to this kind of progression by the length of the posterior extremities, which are nearly double that of the anterior, as may be seen in *fig.* 64.

Fig. 64.—KANGAROOS.

Describe leaping.

CHAPTER XIV.

THE VOICE.

471. The voice in animals and in man consists essentially in the production of sounds expressive of ideas, feelings, passions, and desires.

472. Insects and all water-breathing animals may be said to be mute, since they have no voice. Insects, however, possess the power of producing sounds by certain movements which to some extent are characteristics of the different species. The shrill chirp of the cricket is produced by rubbing the wing-cases against each other. The harsh shriek of the grasshopper is caused by friction of the legs against the wings. The shrill trumpet sound of the mosquito and the busy hum of bees and flies are produced by the rapid motion of the wings while flying. Other sounds are caused by the jaws in the act of masticating, as the remarkable "*death-watch*," so called.*

473. In the air-breathing vertebrata, the production of sounds depends upon the passage of air through a certain

In what does the voice consist? What animals may be said to be mute? Why may they be said to be mute? How do insects produce sounds? How is the chirp of the cricket produced? How is the sound of a grasshopper caused?—the mosquito?—bees and flies? How are other sounds caused? How is sound produced in air-breathing vertebrata?

---

* "———————— A wood-worm,
That lies in old wood, like a hare in her form!
With teeth or with claws, it will bite or will scratch,
And chamber-maids christen this worm a *death-watch*:
Because, like a watch, it always cries click!
Then woe be to those in the house who are sick!
For sure as a gun they will give up the ghost,
If the maggot cries click when it scratches the post:
But a kettle of scalding hot water ejected,
Infallibly cures the timber affected:
The omen is broken, the danger is over,
The maggot will die, and the sick will recover."

portion of the respiratory tube. In reptiles, it is at the point where the trachea or windpipe opens into the pharynx that the vibratory apparatus is situated. The sounds produced by this class are very simple, being little else than a hiss.

474. In birds, the situation of the vocal organ is very different. The trachea opens into the pharynx, as in reptiles, by a mere slit, but the most essential organ is at the lower extremity of the trachea, near its division into the bronchi. This apparatus, which seems to be a kind of drum, is variously formed in different species. In *fig.* 65

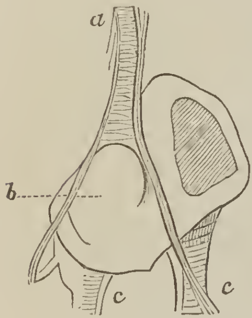


Fig. 65.—Larynx of a species of Duck.
a, trachea; *b*, a kind of bony drum; *c*, bronchial tubes.

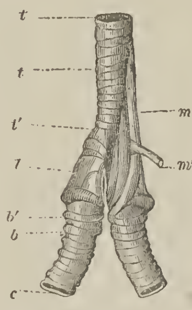


Fig. 66.—Larynx of Rook.

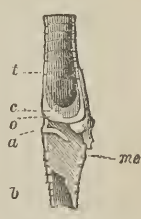


Fig. 67.—Vertical section of the same.

is a representation of the larynx of a species of duck; *fig.* 66 represents the larynx of a rook; and *fig.* 67 a section of the same. At *a*, in each of the above figures, is seen the larynx; at *b*, a sort of bony drum; and at *c*, the bronchial tubes. In the most esteemed singing-birds these parts are much more complicated than in birds not distinguished for their vocal powers.

475. In man and the mammalia, the vocal organ is situated at the upper part of the windpipe, and is called the

Where is it produced in reptiles? How are the vocal organs situated in birds? What does the apparatus resemble? In what birds is it most complicated? Where is the vocal organ situated in man, and what is it called? From what does it receive its peculiar form?

larynx. The larynx receives its peculiar form from four cartilaginous pieces, called the *thyroid*, the *cricoid* and the *arytenoid* cartilages.

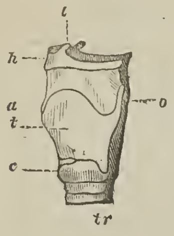


***Fig.* 68.**—HUMAN LARYNX, VIEWED SIDEWAYS.—*h*, hyoid-bone; *l*, point of origin of muscles of the tongue; *t*, thyroid cartilage; *a*, projection in front, commonly called Adam's Apple; *c*, cricoid cartilage; *tr*, trachea; *o*, posterior side of the larynx, in contact with the œsophagus.

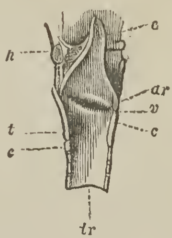


***Fig.* 69.**—VERTICAL SECTION OF THE LARYNX.—*ar*, arytenoid cartilages; *v*, ventricle of the glottis; *e*, epiglottis. The other references as before.

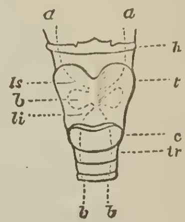


***Fig.* 70.**—FRONT VIEW OF THE LARYNX.—The interior wall is marked by the lines *a*, *a*, *b*, *b*,; *li*, inferior ligaments of the glottis, or vocal cords; *ls*, superior ligaments. The other references as before.

476. The thyroid, (*fig.* 68,) is much the largest and is composed of two symmetrical halves, which meet in front, and form the proturberance in man called "Adam's Apple." It rests below on the cricoid cartilage, and is connected above with the hyoid-bone of the tongue (*h*).

477. The cricoid cartilage (*c*), which is placed below the thyroid (*t*), is the base of the larynx; it has the form of a ring, and is much deeper behind than in front.

478. The arytenoid cartilages are two small cartilaginous bodies, placed upon the upper surface of the back of the cricoid cartilage, where there is an open space left between the two halves of the thyroid cartilage. When joined together, the arytenoid cartilages resemble the mouth or spout of a pitcher.

Which of the cartilages is the largest? Of what is it composed? What protuberance does it form? What is above and below the thyroid cartilage? Where is the cricoid cartilage placed? What is its form? What are the arytenoid cartilages? How are they placed? What do they resemble when joined together?

479. The *chordæ vocales*, or vocal cords, (*a*, *a*, *fig.* 71,) which are the instruments principally concerned in the production of sound, and also in the regulation of the aperture through which the air passes into the trachea, are stretched across from the arytenoid cartilages to the interior angle of the thyroid cartilage. By the meeting of the vocal cords in front, and their separation behind, the aperture has the form of a V, but by the drawing together of the arytenoid cartilages until the cords touch, the aperture is completely closed. In this manner, the amount of air permitted to pass the larynx is regulated, and a protection afforded against the entrance of solid substances, though there is the additional guard of the epiglottis, which is pushed down in the act of swallowing upon the open space above.

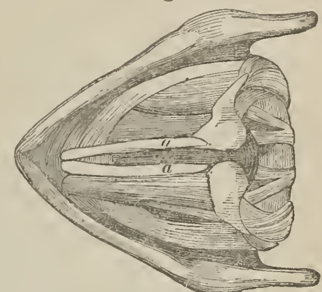


Fig. 71.—BIRD'S EYE VIEW OF HUMAN LARYNX, from above.

480. In the ordinary acts of inspiration, the arytenoid cartilages are wide apart, so that the aperture between the vocal cords is as large as possible; but in the production of vocal sounds the aperture is narrowed, and the vocal cords made tense, so as to vibrate with the passage of air, in a manner resembling the vibration of the tongue of an accordeon, or the reed of a clarionet. The different sounds are caused by the different degrees of tension of the vocal cords. When the tension is feeble, the tone will be grave and dull, and when it is great, the tone will be acute.

481. The tension of the vocal cords is regulated by the

What are the vocal cords, and how are they situated? What is the form of the aperture between the vocal cords? How is it closed? Of what other use is it besides to regulate the passage of air? What other guards has the larynx? What is the condition of the aperture in the ordinary acts of inspiration, in the production of vocal sounds? What does the vibration of the vocal cords resemble? How are different sounds caused? What tone is produced when the tension is feeble?—when it is great?

will with most remarkable precision, and without any consciousness on the part of the individual of the means by which the desired result is produced. The average length in the male in a state of repose is about $\frac{73}{100}$ths of an inch, while in the state of greatest tension it is about $\frac{93}{100}$ths of an inch, making a difference of $\frac{20}{100}$ths or $\frac{1}{5}$th of an inch. In the female the difference is less than $\frac{1}{8}$th of an inch. In this space of $\frac{1}{8}$th or $\frac{1}{5}$th of an inch, there cannot be less than two or three hundred different degrees of tension in what may be called a natural voice, while in a voice highly cultivated, as in some celebrated vocalists, there must be a much larger number—perhaps from one to two thousand.

482. Loss of voice, such as occasionally occurs in public speakers, is caused, not by "*bronchitis*," as is generally supposed, but by relaxation of the vocal cords to such an extent as to lose all control over the size of the aperture between them. In ordinary colds, these cords are sometimes slightly inflamed, producing hoarseness. In inflammation of the vocal cords, the mucous membrane which lines the larynx, the trachea, and not unfrequently the bronchi, may be similarly affected, and hence the disease is commonly called "*bronchitis*."

483. The voice and the power to produce articulate sounds, by which man communicates ideas to his fellows, is one of the most remarkable faculties in his possession, and one in which he is vastly superior to all other animals. By cultivation, the voice can be made greatly to surpass its natural powers, and increase its capacities for contributing to man's usefulness and pleasure, as a social being.

How is the tension of the vocal cords regulated? Have we any consciousness of the tension of the vocal cords? What is their average length in the male in a state of repose?—in the greatest tension? What is the difference in the female? How many different degrees of tension are there in a natural voice?—in a highly cultivated voice? How is loss of voice caused? What other parts are sometimes affected when the vocal cords are inflamed? What is said of the power of producing articulate sounds? How may the voice be greatly improved?

PLATE XXIII.

THE HUMAN FORM.

FIGURE 1.——*A Lady writing, and resting on her left elbow, with the right shoulder raised.*

FIGURE 2.——*A Lady writing, in a Correct Position.*

FIGURE 3.——*A Boy bent forward too much in writing.*

FIGURE 4.——*A Boy resting on his left elbow.*

FIGURE 5.——*A Boy writing in a Good Position.*

FIGURE 6.——*A Good Attitude in standing.*

FIGURE 7.——*A Man walking erect.*

FIGURE 8.——*A Man stooping while walking.*

FIGURE 9.——*A Round-shouldered or Consumptive Form*, caused by the habit of indulging in such attitudes as represented in figs. 3 and 8.

FIGURE 10.——*A Lady riding*, with her spine bent in such a manner as to produce curvature.

FIGURE 11.——*A Lady riding correctly.*

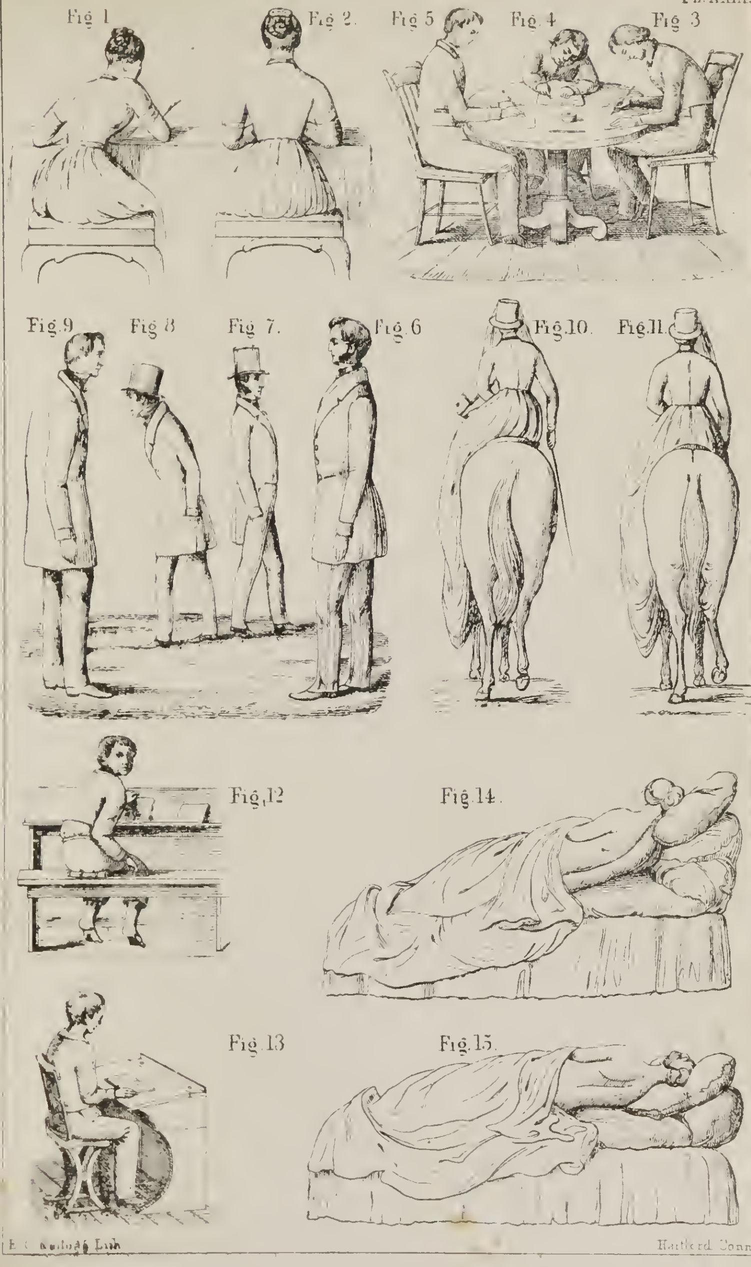
FIGURE 12.——*A Boy at School, on an old-fashioned bench*, so high that his feet cannot touch the floor, and without any support for the back.

FIGURE 13.——*A Boy at School, in a chair, just right*—easy, convenient, and perfectly adapted to his comfort and health.

FIGURE 14.——*A Person bolstered up in Bed*, in such a manner as to form a curvature of the spine.

FIGURE 15.——*A correct position in Bed.*

PL. XXIII.



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CHAPTER XV.

THE HUMAN FORM.

484. THE sublime privilege of standing and walking erect has been exclusively granted to man, and has always been given as one of those characteristics that indicate his vast superiority over all other animals. An erect form is therefore equally essential to the gracefulness and dignity of his external appearance, and to the health of the various internal organs which perform the vital functions.

485. The man whose attitude is erect and commanding, has a nobleness of appearance that never fails to commend him to our respect and esteem; while he who walks with his face to the earth, as if bowing beneath a burden of guilt, or stooping to some debasing act that leads him to shun the face of other men, has an air of inferiority, and seems to inspire more of contempt or pity than of admiration.

486. An erect attitude, and an open breast, is of no less importance to health than to personal appearance. For any deformity which can affect in any degree the form of those cavities which contain the organs of circulation, respiration, and digestion, must be more or less prejudicial to the perfect action of those vital organs.

487. Deformities are sometimes the result of unavoidable disease of some of the bones, but they are generally caused by the habitual indulgence in improper positions.

488. During childhood the bones are soft and pliable, and easily accommodate themselves to any position which is habitual. Thus, the bone of the thigh is often perma-

What has always been given as one of the characteristics of man? What is said of the importance of an erect form? What impression does a man of erect form make on us?—one of a stooping form? What must be the effect upon health of any deformity of the cavities which contain the vital organs? How are deformities usually caused? What is the co dition of the bones during childhood? How may the bone of the thigh be bent?

nently bent by compelling children to sit on a bench so high there is no support for the limbs, except at the centre of the thighs, which rest on the edges of the seat, as in *fig.* 12, Pl. XXIII.

489. The most common deformities are those of the spine and ribs. The ribs are perhaps more easily changed in form than other bones of the body. They are long slender bones, attached to the spine, by ligaments which admit of free motion, to the breast-bone, by flexible cartilages. Their very structure is such, that the constant pressure of the clothing, day after day, needs to be only very slight to bend the ribs downward and inward, as represented in *fig.* 6, Pl. XXIV.; and it is not necessary that there should be very great strength of ligature, or any repeated acts of violence, to materially diminish the capacity of the chest, provided a sufficient length of time be allowed to bring about the result in a genteel way. "*Snug-fitting*" dresses, from fourteen to twenty, are the only appliances needed to make a young lady sadly deformed in chest for life.

490. The deformities of the spine are caused in a variety of ways. The spinal column is composed of twenty-six separate bones, placed one above the other, and separated from each other by a layer of elastic cartilage. The spine is maintained in the erect attitude by the action of numerous muscles and ligaments. When these become weakened by inaction, or by the constant pressure of dress, some portion of the spine is allowed to bend either forward or backward, or to the right or left side. An equal portion above or below bends in an opposite direction, thus forming two curves. The elasticity of the cartilages

What are the most common deformities? What bones of the body are more easily changed in form than any other? Describe the ribs, and the manner they are attached to the spine and the breast-bone. How are the ribs effected by tight dress? How much pressure is necessary to produce deformity of the ribs? How may a young lady be deformed for life? How are the deformities of the spine caused? Describe the spinal column. How is it maintained in the erect attitude? What takes place when the muscles become weakened? How does the deformity become permanent?

is such that they very soon yield to any position which becomes habitual, and thus the deformity gradually becomes permanent.

491. The same curvature of the spine may be effected by the habit of inclining to one side or the other while sitting, and whenever the habit is formed, there is a constant disposition to persist in it. The habit, not unfrequent, commences in resting one elbow, usually the left, on the desk at school, and very soon the same attitude is observed at the centre-table at home; then follows the habit of reclining in bed in such a manner as to favor the same form of the spine. Little by little, the spinal column deviates from a perpendicular line till there is a permanent deformity. Artizans, clerks, writers, and persons whose occupations require the use of the right hand chiefly, are exceedingly liable to a slight curvature, with marked prominence of the right shoulder-blade, unless constant care is observed to prevent it. Teachers and parents cannot be too vigilant of the habits of those committed to their charge. The seats in school-rooms should be so constructed as to favor correct positions. When a child is compelled, for the want of any proper support, to sit several hours each day in a bent position, as represented in *fig.* 12, Pl. XXIII., the anterior edges of some of the cartilages will be absorbed and become thinner, and at adult age, he will stand and walk as represented in *figs.* 8 and 9, Pl. XXIII.

492. Youth should always be furnished with such recreation as shall call into exercise the various muscles of the body. Time for amusement is not alone sufficient; such a variety should be afforded at every school and seminary as shall call into vigorous use the muscles of the limbs, the arms, the body, and the chest. Facilities for exercise

In what other way may curvature of the spine be caused? How does the habit of inclining to one side frequently commence? With what kind of exercise should youth always be furnished? Is time for amusement sufficient? What parts should be exercised in amusement?

similar to those represented in *figure* 9, PLATE XXIV., should be considered as belonging to the necessary fixtures which are indispensable to every well-regulated school. Teachers, too, would not only take better care of their own health, but would increase their usefulness to those committed to their charge, if they would consider it not beneath their true calling to give practical lessons in regard to the physical as well as the intellectual exercises of their pupils. Too little attention is devoted to the physical education of the young, in most of our institutions of learning, and it is to be hoped that, with a more general diffusion of the principles of physiology, this most essential element for the future usefulness and well-being of the young will cease to be neglected.

PLATE XXIV.

HUMAN FORM.

Figure 1.——*A Lady reading, in a good position.*

Figure 2.——*A Lady leaning forward, and resting on one elbow, in a position favoring lateral curvature of the spine.*

Figure 3.——*A Lady sewing, in a good position.*

Figure 4.——*A Lady occupying such a position in sewing as to produce antero-posterior curvature of the spine.*

Figure 5.——*Outlines of a Female Figure, after it has been permanently remodelled by fashionable dress.*

Figure 6.——*Part of the Skeleton of the same, with the thorax reduced to about half its natural size.*

Figure 7.——*Outlines of a Natural Female Figure.*

Figure 8.——*Part of the Skeleton of the same.*

Figures 9 and 10.——*Public School, with Play-grounds for Boys and Girls, supplied with appropriate facilities for recreation and exercise.*

Fig. 2 Fig. 1 Fig. 4 Fig. 3

Fig. 8 Fig. 6

Fig. 7 Fig. 5

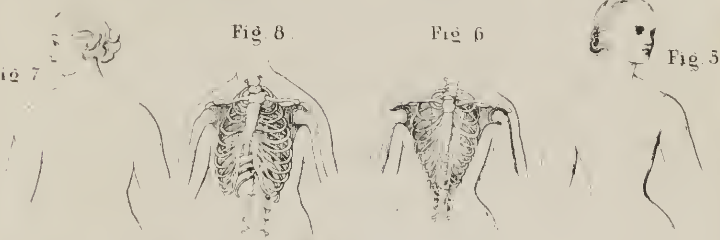

Fig. 9

APPENDIX.

THE AIR WE BREATHE.

1. The earth we inhabit, is surrounded by an atmosphere of air, not less than 45 miles in height. Its pressure, or weight at the level of the sea, is allowed to be 14 pounds to the square inch of the earth's surface. Allowing the surface of a man's body of medium size to be fifteen square feet, or 2160 square inches, he suffers the enormous pressure of more than fifteen tons. Still, as the pressure from within and without is equal, it is unperceived except by its variations. The pressure is the greatest at the level of the sea, and diminishes as we ascend high mountains. The air floats around the earth in almost perpetual motion, and produces gentle breezes, winds, gales, and tornadoes.

2. Atmospheric air, though apparently a simple element, is a mixture of different gases. Its constituents, by weight, are—oxygen, 23.02 parts, nitrogen, 76.98 parts, and a portion of carbonic acid, varying in amount from $\frac{4}{10000}$ to $\frac{6}{10000}$

OXYGEN.

3. Oxygen is the only sustainer of animal life. It unites with nearly every substance on the face of the earth with more or less intensity. When it combines rapidly with any substance

it produces combustion—when slowly, oxydation or rusting. A piece of wood or charcoal, having on it only the slightest spark of fire, will burn with great brilliancy when plunged into pure oxygen. A common watch-spring will burn with a sparkling light, if one end is coated with sulphur, and plunged into this gas the instant it is ignited.

4. When animals breathe pure oxygen, all their functions are increased in activity, and the entire machinery of life is propelled beyond its natural velocity. Man is dependent every moment of his life on the presence of oxygen in the air he breathes. It is constantly combining with the tissues to form carbonic acid and generate heat. It is this which imparts to the blood its life-giving properties, and removes from it those impurities which are constantly formed by the decomposition of the tissues, and which would soon destroy life if they were allowed to accumulate in the body. The brain, which is the controlling organ of the body, is dependent for its energy and power on a due supply of pure oxygenated blood.

5. When oxygen is inhaled freely, it quickens the circulation, exalts the vital functions, and imparts an agreeable stimulus to the mental powers. In breathing an excess of oxygen, men live too fast, and burn away with intense brilliancy, like the taper which is plunged into it. But, when they deprive themselves as multitudes constantly persist in doing, of the natural quantity of oxygen in the air they breathe, all the powers of life, droop and languish, and the tone of health is gradually lowered till some susceptible organ yields to disease.

NITROGEN.

6. Nitrogen is supposed to be useful mainly as a diluent of oxygen. It does not support combustion or animal life, though there is no reason to suppose that it has any pernicious or poisonous properties. A taper plunged in it goes out because there is nothing to support combustion. Animals droop and die in it from exhaustion.

CARBONIC ACID.

7. When pure, carbonic acid is a most active and fatal poison, destroying animal life and extinguishing flame, not from the absence of oxygen, but from the presence of active qualities, which are destructive to life and to combustion. If inhaled pure, it produces a spasm of the throat, and causes instantaneous death; if it is sufficiently diluted to be received into the lungs, it acts as a narcotic, and thus destroys life.

EFFECTS OF BREATHING CARBONIC ACID.

8. Pain in the head, drowsiness, languor, and a sense of fatigue, the mildest symptoms of its poisonous effects, may be experienced in breathing air which contains only one part in one hundred of carbonic acid. In three or four parts lights burn dimly, and are extinguished in five or six. Six or seven parts will produce serious injury to the health, and ten parts prove fatal to life. Persons who confine themselves most of the time in apartments containing only a small excess of carbonic acid, acquire a pale, sallow, and sickly complexion, and ultimately become subject to colds, coughs, bilious complaints, scrofula, or consumption. Mechanics, artisans, and shop-keepers, who occupy in most of our cities close and unventilated shops by day, and, if possible, still closer bed-rooms by night, are twice as liable to consumption alone as those who spend most of their time in the open air. According to the Report of the Sanitary Commission of Massachusetts, 1850, the number of females, compared with the males, who die of consumption in the country towns, is nearly two to one, while in the cities, where the males are confined in-doors more closely than the females, the number of deaths among the males is the largest.

FORMATION OF CARBONIC ACID.

9. Carbonic acid is evolved from burning fuel, lights, open furnaces, lime kilns, &c., and it may be formed in large quantities, by pouring muriatic acid on marble, or carbonate of lime. It

is also a natural product of respiration, and is exhaled from the skin. It is estimated that about four and a half per cent. of the air, as it comes from the lungs in natural respiration, is carbonic acid, making on an average about twelve to fifteen cubic feet per day.

10. During the same period, from three to five cubic feet of carbonic acid escapes from the skin, making in all some fifteen cubic feet daily. But it is a remarkable fact, that if the air which is breathed be previously impregnated with carbonic acid, the amount which is added to the respired air becomes less and less, as the impurity of the air increases. Thus, in a single instance, when fresh air was taken in at each respiration, 32 cubic inches of carbonic acid were exhaled in a minute, while only 9.5 were emitted in breathing air, which had been previously respired. Some efficient means of supplying pure air is therefore demanded in every apartment where carbonic acid is found.

WATERY VAPOR.

11. Besides the usual estimate of carbonic acid, the respired air is found to contain some twenty ounces per day of watery vapor. This vapor, however, is not pure water, it contains carbonic acid, volatile substances, and animal matter. The breath of some individuals possesses an exceedingly offensive and fetid odor from the animal impurities with which it is charged. Turpentine, alcohol, camphor, garlics, and other odorous substances, it is well known, can be detected in the breath for several hours after they have been taken into the stomach. During the progress of febrile diseases, or during temporary derangement of the stomach, the offensive odor of the breath is often greatly increased.

EXCRETIONS OF THE SKIN.

12. The natural excretions of the skin also contribute to the impurities of the atmosphere. The amount of impurities which pass off from the skin is by no means uniform, since they must of necessity vary with the temperature of the air, the amount of

fluid taken, the habits of exercise, and various other circumstances. As a general estimate, the excretions of an adult will not be less than thirty-two ounces each day, while they are often as high as five pounds. Of this, the largest proportion is a watery vapor, which escapes in the form of "sensible or *insensible perspiration*," but about one per cent. consists of solid substances, which are the products of the decomposition constantly taking place in the tissues. The peculiar odor of perspiration is owing to the effete matter which it contains, and is sometimes very offensive on persons who neglect daily ablution.

13. The total quantity of impurities which are daily given off by an adult, are on an average as follows :—

Carbonic acid	14 to 20 cubic feet
Watery vapor	2 to 5 pounds.
Effete animal matter . . .	1 to 2 ounces.

According to Dr. Charles A. Lee, each person vitiates, or renders unfit for respiration nearly four cubic feet of air every minute.* It is therefore necessary in order to preserve the purity of the air, that at least an equal quantity should be changed every minute.

VENTILATION.

14. There is no subject, directly connected with the preservation of health, in reference to which there is so much popular ignorance and indifference as ventilation. All men understand the necessity and importance of providing for themselves food and drink; but for air, the essential element of existence, they make no provision; yet men have been known to live five weeks without food, but a person wholly deprived of air will not live five minutes. We have no appetite and no instinctive impulses which protest against an insufficient supply of air, as against want of food and drink; nor do we realize that bad air is a slow poison, the breathing of which as surely injures the health, as the

* Copland's Practical Medicine, page 138.

habitual use of arsenic, prussic acid, or any other poison. Our indifference, in a matter of so much vital importance, can be accounted for only on the supposition that we are slow to believe that we can be injured by any agent which does not produce an immediate and sensible effect.

15. But it is nevertheless true, that the breathing of impure air is a fruitful source of impaired health and disease. Air which has been breathed over and over again in our parlors, sleeping apartments, school-rooms, public halls, and churches, becomes charged with the dead animal matter which is constantly given off by the skin and lungs, and with carbonic acid gas, the natural product of respiration, and is as truly poisonous as the most loathsome substance in nature. Air thus poisoned, is as unwholesome for the purpose of respiration, and would be as repulsive, if our senses could appreciate it, as decayed animal flesh for the purpose of mastication and digestion.

16. It is now well established, that one of the common causes of typhus fever is the effete matter of the human body, accumulated and long retained in private dwellings. Typhus fever, dysentery, and the cholera, when they prevail as epidemics, not unfrequently take their origin in the impure air which is breathed in camps, in the holds of emigrant ships, and in the abodes of squalid poverty. Though these malignant diseases may not often be generated spontaneously in the unventilated apartments of the affluent, still the health may be gradually impaired, and the seeds of disease insidiously implanted in the constitution. The blanched features, the pale and cadaverous countenance, and the impaired health, with which multitudes come forth from their winter-quarters in the spring, testify very plainly to the pernicious influence of bad air.

17. Till within the last half century, almost the only heat ing apparatus in use was a fire-place, with a depth of from three to four feet, and and a width of from six to eight, and a flue of equally liberal dimensions. When one of these mammoth fire-places was filled with wood, and burning briskly, a volume of rarefied air was constantly driven up the chimney, sufficient to

exhaust in a few minutes the air of almost any room. Under such circumstances, there could hardly fail to be a constant supply of unrespired air, so long as the crevices about the doors and windows were sufficiently open to supply the draft up the chimney. The imperfect architecture of the houses, and its liberal dimensions, made the old fashioned fire-place a noble ventilator.

18. With the disappearance of the forests, and the constantly increasing scarcity of fuel, this noble ventilator has given place to small Franklins, open grates, and air-tight stoves. An open fire, in any form, has some value as a ventilator, though it is not sufficient for all the purposes of ventilation. When this is surmounted by a flue of good draught, it will draw off a portion of the air from the bottom of the room, and thus secure a change of air. But an open fire is liable to this objection, that while the cold air which enters the windows and doors falls to the floor, and flows along to the fire, and becoming heated, rises in the flue, the air that is to be respired in the upper part of the room suffers but little change, and is breathed over and over again, till it is unfit for respiration.

19. But an open fire is vastly better than the air-tight stove, which produces little or no change of air, except the very small quantity required to support combustion.

HOT AIR FURNACES.

20. Hot air furnaces and ventilating stoves are quite modern inventions, and may be regarded as affording one very essential condition of ventilation, namely, a constant supply of pure air. But the system of heating by introducing air that has been previously warmed is not perfect, without some means of exhausting the impure air.

21. Air, as it is delivered from most hot-air furnaces, is at a much higher temperature than the air of the room, and, when admitted through large registers, rushes to the ceiling and forms a stratum of heated air in the upper part of the room, leaving

the air near the floor quite unchanged. If the heated air be introduced through numerous small openings in the floor, and allowed to rise to the ceiling and then pass off, pure air will be secured in all parts of the room.

22. Under any arrangement now in use for producing artificial heat during winter, some means of ventilation must be regarded as indispensable. A great variety of methods have been proposed, but that is to be preferred which is most simple, constant and uniform. The most important principles to be observed may be reduced to the following rules.

RULES FOR VENTILATION.

23. 1st. Each room should be provided with some means for introducing a constant and uniform supply of pure air.

During winter, it will be found most economical, as well as most agreeable, to introduce air which has been previously warmed.

24. 2d. Each room should be provided with a flue or ventilator, of a capacity proportioned to the size of the apartment and the number of its occupants, with two valves or registers for the escape of impure air, one near the ceiling, and the other near the floor.

25. 3d. In private apartments of good size, which are occupied by only a small number of persons, the supply of pure air should not be less than four cubic feet per minute for each person. In school-rooms, churches and public halls, from eight to ten cubic feet per minute will be required.

26. 4th. The valve in the ventilator near the ceiling should be allowed to remain open, and the valve near the floor be closed, when a room is too warm, and when it is heated by an open fire or a close stove, and during warm weather.

27. 5th. The register near the floor should remain open when the room is warmed by heated air, introduced by a hot air furnace, or from a ventilating stove.

28. 6th. Each ventiduct should be so constructed as to secure a constant draft.

This may be accomplished either by heating the ventiduct, or by surmounting it with an exhauster. The ventiduct may be heated by a cast-iron smoke-pipe passed up through it, or by separating it from the smoke-flue by a thin partition.

29. 7th. In summer, when it is necessary to open the windows to secure ventilation, they should, if possible, be open at the top and bottom, and on opposite sides of the room, though no person should remain directly in the current of cold air, unless protected by suitable clothing, or by active exercise.

DIET.

30. Man is less uniform in his diet, and suffers more in consequence of it, than any other animal. All other animals are directed by instinct to select only those substances which are best adapted to their wants. Man is endowed with reason to enable him, by the exercise of thought and reflection, to make his choice of the bounties of Providence. He should, therefore, select his daily food with as much forethought and care as he would select the materials for his dwelling. He should consider, not what will gratify his taste, but what will build up and strengthen his bodily structure, and secure most perfectly the highest and most permanent enjoyment of all his faculties.

CHOICE OF FOOD.

31. The kind of food which each individual should select is by no means uniform. The climate, the season of the year, the occupation, the temperament, the age, the habits of life, and various other circumstances, which might be enumerated, demand modifications of diet.

MODIFICATIONS OF AGE

32. The constituent elements of the body are not found in the same relative proportions at different periods of life, or in different individuals of the same age. In middle life the muscular system predominates, and the body is remarkable for the

compactness of its fibre, its strength, and its power of endurance. In the child there is an excess of fluids, which renders the body more plump and round, and the form beautiful, though more frail and delicate than at a later period. In advanced age the soft tissues have become greatly diminished, and the form wrinkled and wasted.

TEMPERAMENT AND OCCUPATION.

33. In different individuals of the same age, there is a dissimilarity of structure and constitutional peculiarities, quite as remarkable as in those of different ages. One possesses large and powerful muscles, by which he is enabled to accomplish a great amount of physical labor, and to perform remarkable feats of strength and endurance. Another, with a larger brain, but with smaller and weaker muscles, has "a lean and hungry look," and is distinguished by the powers of his intellect. Another is "fat and sleek-headed," and follows a life of ease and indolence. In short, there are almost as many peculiarities of constitution, temperament and occupation, as there are individuals. Each person should, therefore, have a diet adapted to his own peculiarities.

CLIMATE.

34. The inhabitants of cold climates require those articles of food which produce the largest amount of animal heat; such as oil, tallow, and fat meats, which contain from 66 to 80 per cent. of carbon. The natives of the arctic regions consume enormous quantities of fat and oil, and seem to relish them as great luxuries. The inhabitants of tropical regions subsist mainly on rice, fruits, vegetables, and lean meats. It would be impossible to live in Greenland on the plaintain and rice of the Hindoo, or in Hindoostan on the seal fat and whale oil of the Greenlander.

SEASON OF THE YEAR.

35. In temperate climates we require different kinds of food at different seasons of the year. In winter we consume larger

quantities of fat meat and other carbonaceous food, and in summer more fruit and vegetables. Were we to indulge in summer in the same diet which we might find highly conducive to health during winter, the system would very soon become burdened with an excess of carbonaceous matter, and induce congestive and inflammatory diseases. It is, therefore, highly important that each person should possess some knowledge of the properties of different articles of diet, and select, from time to time, such as he thinks most suitable for his own organization.

PROPERTIES OF ALIMENTARY SUBSTANCES.

36. Different substances are nutritious in proportion as they yield, when digested, those elements which are found to exist in the various tissues of the body. Animals do not possess the power of forming new elements, or of converting one element into another, and it necessarily follows that the elements of their growth and nutrition must be derived from the food which they take. The largest part of nearly all the substances which make up the human body, are composed of *oxygen*, *hydrogen*, *nitrogen* and *carbon*, and different substances are regarded as nutritious in proportion as they furnish these essential elements of all animal organization. In general, those substances may be regarded as the most valuable articles of diet which furnish, with the greatest facility of digestion, the largest amount of these elements.

MILK.

37. Milk is regarded, perhaps correctly, as the simplest and plainest kind of food. Unlike almost any other article of diet, it embraces all the necessary elements for the nutrition of the body, and contains these elements in a form peculiarly adapted to the young of all the mammalia. Perhaps no one article of food is more widely diffused among all races of men than this. The Laplander, within the Polar Circle, is provided with milk as an important part of his diet by the reindeer. The Arabs, in the burning desert of the tropics, obtain this nutriment from their camels, their sheep, and sometimes from their goats. In

all civilized countries, the cow is to be found—in the densely populated cities,—and by the log-cabin of the pioneer. Cow's milk is composed of—

Casein, ...	4·48
Butter, ...	3·13
Sugar of Milk, ...	4·77
Various Salts, ...	·60
Water, ...	87·00

38. Milk, being furnished by nature as the only food for the young of the mammalia during a certain period of their existence, contains all the elements necessary for the nutrition and growth of the body. "Out of the casein are formed the albumen and fibrin of the blood. The butter serves for the formation of fat, and contributes, with the sugar, to support animal heat by yielding carbon and hydrogen to be burnt in the lungs. The earthy salts (phosphate of lime, &c.) are necessary for the development of the bones. The iron is required for the blood-corpuscles and the hair." Milk is a highly useful and valuable article of food, as well for the adult as the child—for healthy individuals, as for invalids and convalescents.

FISH.

39. An almost endless variety of food is furnished to man by the numerous genera and species of fish. Among some nations, it constitutes the major portion of their diet. Fish are less nourishing and less satisfying to the appetite than the flesh of either birds or the mammalia. Those kinds of fish which abound in oil, as salmon and eels, are more nourishing, but less digestible than haddock, sole, flounder, cod or turbot.

40. The digestibility of fish is very much diminished by the process of salting, smoking, and drying. The watery portion is thereby diminished, causing a larger amount of nutritive matter to be taken in proportion to the bulk. A fish diet is less substantial than either butcher's meat or poultry. It may be employed when the digestive organs are unable to assimilate stronger

kinds of aliment, when it is necessary to avoid the stimulus which butcher's meat communicates to the system. Fish is better adapted to the wants of the system during the warm season than the cold; since the flesh of the more digestible kinds is less stimulating, and contains a smaller proportion of carbonaceous or heat-producing elements. The quantity of nutritive matter found in some kinds of fish has been stated as follows :—

100 parts of Muscle.	Water.	Albumen or Fibrin.	Gelatin.	Total of Nutritive Matter.
Cod, . . .	79	14	7	21
Haddock, . .	72	13	5	18
Sole, . . .	79	15	6	21

OYSTERS.

41. Oysters hold a high rank as a delicious and favorite article of food, which is easily digested by most persons, though they unquestionably disagree with some constitutions. They are more easily digested when raw than when cooked, according to the experiments of Dr. Beaumont.

DIGESTIBILITY OF OYSTERS.	H.	M.
Raw, ...	2	55
Roasted, ...	3	15
Stewed, ...	3	30

42. During the warmest weather, fish and oysters are both unsafe articles of diet unless used very soon after they are removed from the water. But for those who are favored either with a temporary or a permanent residence on the sea-shore, both may be regarded as a highly useful and agreeable diet.

LOBSTERS

43. Lobsters, though highly esteemed by epicures, are very difficult of digestion, and not to be included in the list of articles proper to be indulged in by those who prefer health to the gratification of appetite.

MEAT.

44. In this country meat constitutes an important part of the diet of almost every family. As a general rule, animal food is more easily digested, contains a greater quantity of nutriment, and is more stimulating than any of the varieties of vegetable food. The following is the composition of the kinds of meat in most general use.

100 parts of Muscle.	Water.	Albumen or Fibrin.	Gelatin.	Total of Nutritive Matter.
Beef, . . .	74	20	6	26
Veal, . . .	75	19	6	25
Mutton, . .	71	22	7	29
Pork, . . .	76	19	5	24
Chicken, . .	73	20	7	27

45. As minuteness of division and tenderness of fibre facilitate digestion, young meats are more tender than old. Thus, roasted pig, according to Dr. Beaumont's experiments, was more speedily digested than broiled pork. Steak and boiled lamb, sooner than boiled mutton. Still, there are some exceptions to the digestibility of young meats. Veal, and, with some persons, lamb, are slower of digestion than beef and mutton.

VEGETABLE FOOD

46. The vegetable kingdom greatly exceeds the animal in the number and variety of the aliments which it furnishes to man. The chief nutritive principles in vegetables are gluten, starch, sugar, gum and oil. The alimentary qualities of different kinds of vegetable food will be found to depend on the quantity and the proportions in which these principles exist. The composition of each of these principles is given in the following table:

	Carbon.	Hydrogen.	Oxygen.	Nitrogen.	Water.
Gluten,	55·22	7·42	21·38	15·08	
Starch,	37·5				62·5
Sugar,	42·85				57·15
Gum,	36·3		10·828		63·7
Oil,	77·403	11·481		2·888	

47. It will be seen by the above table that the four essential elements, Carbon, Hydrogen, Oxygen, and Nitrogen, which form an important part of all animal compounds, are also to be found in great abundance in vegetable compounds. It is owing to this fact that different animals are nourished equally well on an exclusive diet of either. The lion, tiger, and other animals which live exclusively on animal food, give no evidence of being better nourished than the deer, the ox, and those animals which subsist wholly on vegetable food. But the apparatus for digestion in each class is constructed with an evident adaptation to the kind of diet on which the different animals subsist. Those animals which live on vegetable aliment are provided with organs more complicated than those which subsist on the flesh of other animals. In man, the digestive apparatus is more extensive than in flesh-eating animals, but is less complicated than in those which are confined to vegetable food alone. Man is therefore omnivorous, both in his structure and in his habits.

48. Instances are not wanting, however, in which men have lived in the apparent enjoyment of health on an exclusive diet of each. Thus, Sir Francis Head states in regard to the Guachos, inhabitants of the Pampas in South America, "that they often continue on horseback day after day, galloping over their boundless plains, under a burning sun, and performing labors almost of an incredible description. The constant food of the Guachos is beef and water. His constitution is so strong that he is able to endure great fatigue, and the distances he will ride, and the number of hours he will remain on horseback, would hardly be credited." The inhabitants of India and most tropical countries subsist almost entirely on a vegetable diet.

49. But the universal tendency of mankind gives preference to a mixed diet. The most perfect physical development and the greatest intellectual vigor are to be found among those races in which a mixed diet is the prevalent habit.

USE OF FRUIT.

50. During the warm season, vegetables and fruits may be made the means of great mischief or of great good. Perfectly ripe fruits and vegetables are highly useful, and well adapted to the wants of the system at this season of the year. Yet they may become, and often are, a most prolific source of disease. So frequently is this kind of food a cause of bowel complaints, that most city physicians discard it wholly from the diet of children not under their own personal supervision. Some prohibit their use to adults. Vegetables and early fruit that have been long exposed in a malarious or filthy market, or in transportation, are unquestionably dangerous articles of food for all persons. But the injurious consequences which follow the use of ripe and wholesome vegetables and fruit, are in almost all cases the results of imprudence. They are either in an improper condition to be used as food, or the quantity is too great, or it is taken at improper hours. Many families use this kind of food only occasionally, and then it forms an important part of a meal, or is indulged freely at other hours. In either case, there is a very great change from the usual diet. Instead of a lack of refrigerant and laxative food, there is now an excess of it. Active fermentation takes place in the process of digestion, and results in serious derangement of the whole alimentary canal, which leads to cholera-morbus, diarrhœa, or dysentery.

51. During warm weather, vegetables and fruit are to be regarded as safe only when used as an accompaniment to other food. They are not adapted to meet all the wants of the system, and therefore should not constitute a full meal at any time. In the country, where this kind of food is enjoyed daily, in a proper condition to be eaten, injurious consequences are quite rare, and then they are the result of excess, or of an indulgence of the appetite at irregular hours. Children are remarkably fond of fruit, as well as sugar, and there seems to be in their constitutions some inherent demand for these articles. No part of their diet apparently conduces more to their health and happiness, when they are allowed it at proper times, and as a portion of their daily

food. But children are so prone to excessive indulgence in the various kinds of fruits, that great caution is necessary to prevent the most serious evils. Much care is also requisite to prevent imperfect mastication of this kind of food. Orange-peel, and the skins and stones of cherries, plums and grapes, are wholly indigestible, and often cause serious mischief when swallowed.

Cucumbers, beets, green potatoes, green fruit of all sorts, should be wholly discarded from the diet of children.

DRINKS.

52. Water, in some form, is more essential to our existence than any of the solid aliments we have considered, and is next in importance to the performance of the vital processes, to the air we breathe. Water enters into the formation of all the various tissues of the body, and constitutes a very large proportion of the human system. The blood contains about eighty per cent.; the flesh about seventy-six per cent. of water; and of the entire human body at least seventy-five per cent., or three fourths of its weight, is water. The most important purposes in the animal economy, are accomplished through this medium. In the blood, the solid vital elements are transported by the medium of water from one part of the body to another in a form and condition to promote the vital changes which are constantly taking place. In exhalation, secretion and absorption, the presence of water is indispensable. It acts as a solvent of various alimentary substances, and thus assists the stomach in the act of digestion. Though when taken in large quantities immediately after eating, it dilutes the gastric juice, and hinders digestion. Water enters more or less largely into the composition of all alimentary substances, and is taken into the stomach in a pure state, or forms the principal part of the various kinds of drinks in use.

53. Water is unquestionably the natural drink of adults, and meets the wants of the body more perfectly than any or all of the artificial liquids which are regarded as improvements on the simple drink Nature has designed and universally provided for man

and beast in all parts of the earth. Whenever a man is left to the cravings of instinct, unbiased by a vicious appetite, he invariably resorts to water as the natural means to quench his thirst, cool his system, and invigorate his wasting strength. " Next to the nutritive fluid furnished by the maternal bosom, water is the one taken with avidity by the infant, as, if left to his primitive taste, it ever would be by adult man ; and even he who, in the madness of his evening revel, drinks deep of the intoxicating bowl, and stoutly denies the fitness of water as a beverage, will on the following morning entreat for and clasp with eagerness the full pitcher of this liquid, which a few hours before he had so resolutely derided. Both interest and recovered reason now suggest the choice of the proper beverage ; and, but for the curse of imitation and evil example, their joint influence could never be mistaken."

54. " When we say that water is the only fitting drink for man's daily and habitual use, we are sustained by the facts of the case. Water is the only liquid which is essential to the formation, development, and support of his frame : it is equal to all the exigencies of thirst, for the relief of present inconvenience, and of dilution, by mixing with his blood, and other fluids, to prevent farther suffering and disease. Water is found in all climates and habitable regions of the earth ; and Providence has nowhere offered, in fountain, stream or well, in river or in lake, any liquid as a substitute for water. To be the universal beverage, it ought to be, as it is, every where attainable, and adequate to all our natural wants,—of appetite, growth, bodily and mental exercise, and activity. Even when the health suffers, and the body and mind are ill at ease, where is the restorative liquid or agent of any kind which can revive and renovate like water,—whether taken alone, in its purity, or with some slight saline and mineral impregnation ! It is the beneficent menstruum and conductor of medicinal matter into the blood ; end even when they are refused entrance, it readily finds its way, and not seldom accomplishes the cure for which they are lauded."

55. In fevers and inflammatory diseases, water quenches the

stimulating quality of the blood, increases its aqueous part, promotes the action of the secreting organs, and is a most efficient means for reducing the fever and allaying the burning heat.

DIGESTIBILITY OF ALIMENTARY SUBSTANCES.

56. The facility with which different alimentary substances are digested, depends on a variety of circumstances. Some kinds of food are naturally more difficult of digestion than others. This is especially the case with all oily or fatty substances, which contain a large amount of nutritive matter in a concentrated form. Tenderness of fibre renders the digestive process more easy, and therefore all those circumstances which affect the texture of flesh have an influence on its digestibility. Violent muscular exertion immediately previous to the death of the animal renders the flesh more easy of digestion. The flesh of young animals, though more tender than that of the adult animal, is frequently not so easily digested. Of adult animals, the youngest will be found more tender and digestible than old animals. Vegetables are generally more slowly digested than meat. Minute division facilitates digestion : hence, if food is perfectly masticated, the process of digestion will be more rapid than otherwise.

COOKING.

57. The art of cooking has as much or more to do with the digestibility of food than any circumstance belonging to the food itself, or the manner in which it is received into the stomach. The immediate object which civilized nations seem to aim at in the art of cooking is, the gratification of the palate. The more important purpose of promoting digestion is quite a secondary object. Cooking, for the most part, produces no chemical change in the constitution of food. It simply destroys its organization, and softens its texture.

BOILING.

58. Boiling is the process best suited to facilitate digestion. It softens the fibrous texture of meat, and renders it more solu-

ble in the gastric juice, while the oily and more indigestible portions of the meat are melted out. In the case of vegetables, boiling effects the solution of gummy and saccharine substances, and sets free the volatile oils.

ROASTING.

59. Roasting and broiling are both regarded as unobjectionable and next to boiling. Meat, when roasted or broiled, is more digestible when well done than when rare—provided it be not overdone. When thoroughly cooked, it contains less oil than when rare.

FRYING.

60. Frying is the most objectionable of all the ordinary processes of cooking—for the reason that meat prepared in this way contains a larger amount of oil than by any other process. Eggs, omelets, pan-cakes, fritters, fish, livers, and other dishes cooked by frying, are difficult of digestion for weak stomachs. Butter and all fat substances when melted, set free their fixed oils, and become indigestible. Thus, drawn butter, buttered toast, butter cakes, pastry, marrow, and suet-puddings, are all difficult of digestion, and "lie heavy on the stomach."

PASTRY.

61. The whole process of pastry-cooking is at war with digestion, and cannot be indulged in with impunity by persons of weak stomachs and dyspeptic habits. Articles of food that are naturally easy of digestion, when uncombined with other articles, become most obnoxious to the digestive organs by being compounded together. Thus, eggs, flour, butter, bread, and sugar, are each very wholesome, and readily digested when eaten separately; but when the eggs and butter are combined with the flour and sugar to form rich cake, the compound may almost defy the powers of the human stomach. Eggs, too, when rarely boiled, will not offend the most delicate stomachs, but when fried hard in animal

fat or butter, they are exceedingly difficult of digestion by the most vigorous. All compounds, or such as are formed by cooking several simple articles of diet in combination, are found more or less indigestible, according to the richness of the compound.

62. The mean time required for the digestion of different articles of diet is shown in the following table:

TABLE.*

Articles of Diet.	Preparation.	H.	M.
Beef-steak	Broiled	3	
Pork, recently salted	Raw	3	
Pork, recently salted	Stewed	3	
Mutton, fresh	Broiled	3	
Mutton, fresh	Boiled	3	
Soup, bean	Boiled	3	
Chicken soup	Boiled	3	
Aponeurosis	Boiled	3	
Dumpling, apple	Boiled	3	
Cake, corn	Baked	3	
Oysters, fresh	Roasted	3	15
Pork, recently salted	Broiled	3	15
Pork steak	Broiled	3	15
Mutton, fresh	Roasted	3	15
Bread, corn	Baked	3	15
Carrot, orange	Boiled	3	15
Sausage, fresh	Broiled	3	20
Flounder, fresh	Fried	3	30
Catfish, fresh	Fried	3	30
Oysters, fresh	Stewed	3	30
Beef, fresh, lean, dry	Roasted	3	30
Beef, with mustard, &c.	Boiled	3	30
Butter	Melted	3	30
Cheese, old, strong	Raw	3	30
Soup, mutton	Boiled	3	30
Oyster soup	Boiled	3	30
Bread, wheat, fresh	Baked	3	30
Turnips, flat	Boiled	3	30
Potatoes, Irish	Boiled	3	30

* This table is made up from the observations of Dr. Beaumont on the process of digestion in the stomach of Alexis St. Martin.

Articles of Diet.	Preparation.	H.	M.
Eggs, fresh	Hard Boiled	3	30
Eggs, fresh	Fried	3	30
Green corn and beans . . .	Boiled	3	45
Beets	Boiled	3	45
Salmon, salted	Boiled	4	
Beef	Fried	4	
Veal, fresh	Broiled	4	
Fowls, domestic . . .	Boiled	4	
Fowls, domestic	Roasted	4	
Ducks, domestic	Roasted	4	
Soup, beef, vegetables, and bread .	Boiled	4	
Heart, animal	Fried	4	
Beef, old, hard, salted . . .	Boiled	4	15
Pork, recently salted . . .	Fried	4	15
Soup, marrow bones . . .	Boiled	4	15
Cartilage	Boiled	4	15
Pork, recently salted . . .	Boiled	4	30
Veal, fresh	Fried	4	30
Ducks, wild	Roasted	4	30
Suet, mutton	Boiled	4	30
Pork, fat and lean	Roasted	5	15
Tendon	Boiled	5	30
Suet, beef, fresh	Boiled	5	30
Rice	Boiled	1	
Pigs' feet, soused	Boiled	1	
Tripe, soused	Boiled	1	
Eggs, whipped	Raw	1	30
Trout, salmon, fresh . . .	Boiled	1	0
Trout, salmon, fresh . . .	Fried	1	30
Soup, barley	Boiled	1	30
Apples, sweet, mellow . .	Raw	1	30
Venison steak . . .	Broiled	1	35
Brains, animal	Boiled	1	45
Sago	Boiled	1	45
Tapioca	Boiled	2	
Barley	Boiled	2	
Milk	Boiled	2	
Liver, beef's, fresh . . .	Broiled	2	
Eggs, fresh	Raw	2	
Codfish, cured, dry . . .	Boiled	2	
Apples, sour, mellow . . .	Raw	2	

Articles of Diet.	Preparation.	H.	M.
Cabbage, with vinegar	Raw	2	
Milk	Raw	2	
Eggs, fresh	Roasted	2	15
Turkey, wild	Roasted	2	18
Turkey, domestic	Boiled	2	25
Gelatine	Boiled	2	30
Turkey, domestic	Roasted	2	30
Goose, wild	Roasted	2	30
Pig, sucking	Roasted	2	30
Lamb, fresh	Broiled	2	30
Hash, meat and vegetables	Warmed	2	30
Beans, pod	Boiled	2	30
Cake, sponge	Baked	2	30
Parsnips	Boiled	2	30
Potatoes, Irish	Roasted	2	30
Potatoes, Irish	Baked	2	30
Cabbage, head	Raw	2	30
Spinal marrow, animal	Boiled	2	40
Chicken, full grown	Fricassed	2	45
Custard	Baked	2	45
Beef, with salt only	Boiled	2	45
Apples, sour, hard	Raw	2	50
Oysters, fresh	Raw	2	55
Eggs, fresh	Soft Boiled	3	
Bass, striped, fresh	Broiled	3	
Beef, fresh, lean, rare	Roasted	3	

63. The preceding table cannot be taken with full confidence of its accuracy in all cases, since the observations were made under a variety of circumstances, which might influence the length of time in some instances. The rapidity of digestion, as Dr. Beaumont himself shows, varies greatly, according to the quantity eaten, the amount and nature of the preceding meal, the state of health and of weather, and also the state of the mind.

VARIETY OF FOOD.

64. Some variety of food is unquestionably more agreeable, and more conducive to health, than a diet limited to one or a very few simple articles. Accordingly, we find that, wherever

the condition of men will admit of it, they universally make use of more or less variety of alimentary substances, and that this variety increases very much in proportion to the wealth and ability which exists to gratify the desires of the palate, till multiplied luxuries become the sources of unnumbered physical evils.

65. Too great a variety of alimentary substances, whether simple aliments or the compounds of skilful cookery, is always injurious when it becomes a temptation to excess. Few men who habitually burden their stomachs with a little of all the luxuries which find a place on many public and private tables, can long escape the just punishment of violated physical law. The stomach has imposed on it not only the digestion of an excessive amount of food, but a great variety of different substances, which, collectively, become far more difficult of digestion than a meal that is made from a smaller number of articles. In this country, the means of living are so abundant, and so easily obtained, that there is a constant tendency to an excessive indulgence of the appetite. Thus, a much larger amount of food is taken than the wants of the body require, and more than the digestive organs have the capacity to dispose of. Second courses, served up in every variety of style, to gratify the pride of the host, too often overpower the stomachs and stupefy the intellects of the guests, whose complimentary encomiums they were designed to call forth.

66. It is impossible to point out to each individual the kind of diet which will suit best. This, to some extent, must be a matter of personal observation and experience. Peculiarities of constitution, habits of life, age, sex, &c., require modifications of diet, in accordance with the natural wants of each individual. The aged, whose powers of life are feeble and languid, demand a more stimulating diet than at any other period of life, while children demand a generous, but plain and unstimulating diet. Abstinence from all that is found or suspected to be injurious, uniform hours, and temperate indulgence, should be observed by all who value lasting health more than the mere temporary gratification of the palate.

THE TEETH.

IMPORTANCE OF SOUND TEETH.

65. Good teeth are indispensable to health, and to personal beauty. The matter which is continually forming and exuding from the cavities of decayed teeth, and passing with the air we breathe to the lungs, and with the food to the stomach, is an exceedingly unwholesome and pernicious virus. As the process of decay goes on, and the cavities of the teeth enlarge, they become receptacles for the lodgment of particles of food which may be found in every stage of putrefaction, mingling with this virus, polluting the breath, and impairing the health. Of all the loathsome gases the physician is compelled, from his profession to inhale, none are more offensive and loathsome than those which arise from the decomposition constantly going on in decayed teeth.

DECAY OF THE TEETH.

66. The reason why the teeth often decay so early in life, is usually not from any natural defect, but from the manner in which they are used; though impaired health during the period when the teeth are growing, may cause them to be imperfectly organized, and consequently to be less durable in structure. Improper and unwholesome food during the same period may have a similar effect, from the imperfect manner in which the body is nourished. It will be found by observation, that the teeth of children who are indulged in candies, pastry, cakes, and rich food, decay much younger than the teeth of those who are confined to an abundance of plain and wholesome food.

67. An accumulation of foreign substances between the teeth, and around the roots, favors decay of the teeth, by separating the gums from the crown of the tooth, and thereby exposing its neck and roots which are unprotected by enamel. So long as the crown is perfectly protected by the enamel, and the neck and roots by the gums, the tooth cannot decay.

68. The decay of the teeth is not caused by their natural use, for in those persons who chew their food principally on one side,

it will almost invariably be found, that the teeth on the opposite side decay first.

69. Decay of the tooth never commences on the smooth portion, which is most worn by use, but in those portions where the food and other foreign substances are most liable to be deposited. The surface next to an adjoining tooth, the depression sometimes found in the top of molar teeth, and the space around the neck of the tooth, will prove to be the first points of decay.

HOW TO PRESERVE THE TEETH.

70. The great secret of preserving the teeth, is in keeping them clean. As long as every part of a tooth is kept clean, it cannot decay.

71. To keep the teeth clean, requires care and attention. A soft brush is to be preferred. This is to be used carefully and thoroughly, not only crosswise of the teeth, but lengthwise, and in all directions necessary to remove tartar, bits of food, or any other foreign substances. Finely pulverized charcoal, orris root, or myrrh, may be required occasionally, but the use of all acids and corrosive substances, should be carefully avoided.

72. When decay commences, it should be arrested as soon as possible. The dentist should be applied to, and the cavity filled with gold, which will always prove to be well invested. When the decay has progressed so far as to be beyond the dentist's skill to save the tooth, it should be immediately extracted.

EXERCISE.

NECESSITY OF EXERCISE.

73. Next to air, food, and warmth, our bodies demand exercise. We cannot live for any great length of time in the full use and enjoyment of all our faculties and powers, without a certain amount of strength. Strength can be secured and retained only by exercise. Those who attempt to live without exercise, gradually, though often unconsciously, lose strength till they become weak and frail, with little or no power of endurance. It is well known that animals which are constantly confined in

stables, are not as healthy as those which are permitted to roam at large. Even trees which have grown in a dense forest, are not as strong and tough as those that have stood in the open field, where they have been freely exercised by the wind.

74. We have no useless organs. Every organ has its use and its purpose. The muscles which constitute the great bulk of the body, are designed for motion. They not only serve as organs of locomotion to the whole body, but their use imparts activity to all the other organs. Muscular action causes the blood to circulate more thoroughly and freely through all the organs and tissues, and imparts increased energy to the vital changes which take place in the nutrition and growth of the body.

ADVANTAGES OF EXERCISE.

75. The advantages which arise from exercise are very apparent, when we contrast those who exercise with those who do not. Those who take a liberal amount of exercise, enjoy life better, and can make themselves more useful than those who are indolent and inactive in their habits. The man who lives an active, stirring life, possesses a noble form, a strong arm, a generous heart, and a happy frame of mind; and enjoys life, and makes his friends around him comfortable and happy. Life with such a man is real and earnest. How different the sedentary man! With him, every day brings its trials and vexations; its pains and its aches, neuralgia, dyspepsia, and a thousand ills that the active man is a stranger to, torment him, and make his existence so miserable, that life itself is a burden. Instead of quiet, refreshing sleep, he experiences restless nights, disturbed by dreams and visions, still more unpleasant than the realities of the day; he has no appetite for food; no enjoyment of society; no comfort in any thing.

THE CONSEQUENCES OF NEGLECT, NOT ALWAYS IMMEDIATE.

76. The consequences of neglecting exercise, are not seen and felt immediately. Every person in health may be said to have in

store a certain amount of strength, or a certain capacity of endurance. So long as this lasts, no inconvenience will be experienced, but when it becomes wasted, want and distress follow, and the bankrupts in health seldom regain what they have lost. Some more susceptible or more abused organ fails to perform its appropriate office, or becomes diseased, and he that might have been healthy and vigorous, is an invalid for life, or a diseased man hastening to a premature grave. In one person there is a predisposition to lung complaints; in another, the eyes are more susceptible, or are more abused; and in another the stomach. Thus consumption, dyspepsia, weak eyes, and various other affections, which have little or no resemblance to each other, have a common origin in a neglect to use that daily exercise which is indispensable to permanent health.

CHOICE OF EXERCISE.

77. To secure the greatest benefit from exercise, it should be pleasant and agreeable. When taken as an unwelcome necessity, or as an act of penance for physical sins, or when we dislike it as we do nauseating medicine, exercise can do comparatively little good. As a general rule, therefore, that exercise which is most agreeable, or that which interests and diverts the mind, will be found most useful.

78. There should also be a variety of exercise. No one set of muscles should be used to the neglect of others. To secure symmetry and elegance of form, all the muscles must be called into use. If a portion only are used, they will be fully developed, while all the others will remain weak and small. Thus a student whose only exercise is walking, will secure a good full development of the lower limbs, while the muscles of the arms, back, and chest, will remain weak and small.

79. We need recreation as well as exercise. The laborer or mechanic may suffer for the want of something to excite the nervous system, though constantly at work. Only certain muscles are called into use, and they have become so familiar with the daily routine of labor, that the vitalizing energy of the nervous

system is not excited. A physician, as the author can testify from experience, may be literally worn out with continuous riding, and yet suffer extremely for want of some exercise to give new life and action to his system; but let him exchange places for a few hours each day with the mechanic, and both will receive decided benefit. All persons in active life require occasionally that variety which can be secured only by relaxation from accustomed labors, and recreating in a change of pursuits. Students, and all persons of sedentary habits, demand recreation as well as exercise, and are especially benefited by vacations, in which there is a period of exemption from study, and an entire change of scenes and pursuits.

MANUAL LABOR.

80. Manual labor is no doubt valuable, as promoting health and securing muscular strength, but it does not meet all the wants of a majority of those who are engaged in intellectual labor. It fails to interest the mind and excite the nervous system. Manual-labor schools may be adapted to educate men for a business-life, but they have thus far failed to accomplish the object for which they were specially designed. With a majority of students, the hours allotted to work very soon become a burden, rather than a pleasure. Now and then, one turns from study to labor with pleasure and delight, and is highly benefited.

Some are most interested in field sports, or in the various games of quoits, ball, wicket, &c., or in gymnastic exercises; others can more happily combine usefulness and pleasure in manual labor. Young ladies, if they choose, will find the broom and brush very efficient instruments of exercise. The sedentary of the other sex may be equally benefited by using daily the saw and the axe, and find sufficient pleasure in the evidences of their skill and power which pile up before them. Gardening, too, in the season of it, to those who are fond of nature, as exhibited in the uprising shoot and the opening bud and flower, affords the means of most wholesome exercise to the body, and most interesting diversion to the mind.

JOURNEYING.

81. Journeying by a private carriage is a very happy combination of exercise and recreation, and should always be preferred by students and literary men; but riding in railcars and steamboats, thought it may afford recreation, furnishes but very little exercise for the muscles.

HORSEBACK-RIDING.

82. Horseback-riding is a most efficient and elegant means of exercise, and is admirably adapted to promote health in all persons. With a spirited horse, the mind and feelings are often most intensely interested, and every particle of blood in the body receives a new impulse, and circulates with renewed activity through all the vessels. Each organ is jolted and jostled till a new life is imparted to the whole system. To one who has learned how to appreciate this noble animal, horseback-riding is a most delightful mode of exercise and amusement.

GYMNASTIC EXERCISES.

83. Gymnastic exercises, which had their origin in the athletic games of ancient Greece, are remarkably adapted to the strengthening and growth of the muscular system. They consist in performing feats of strength and agility in the acts of balancing, climbing, leaping, running, vaulting, &c. The muscles acquire greater size and strength by this kind of exercise than by any other.

CALISTHENICS

84. Calisthenics is a name given to a gentler sort of gymnastics suited to ladies. The triangle, hoop, ball, dumb-bells, horizontal bar, bow and arrow, nine pins, &c., are all appropriate exercises for girls or young ladies, and are admirably adapted to produce vigorous muscles, graceful movement, and symmetry of form.

85. Gymnastic or calisthenic exercises should be practised very moderately by the inexperienced. Persons who are unaccustomed to the violent muscular effort required in some of the more active exercises, are very liable to produce lameness, or even more serious injury, by over-straining the muscles. Some caution is also necessary to avoid taking cold, after severe exercise. It is usually better to walk a short distance, or take some light exercise, before sitting down.

WALKING.

86. Walking is, perhaps, of all other exercises, the most to be commended. When practised as it should be, at the rate of from four to five miles an hour, walking brings into exercise a large number of muscles, affords a constant variety of objects to interest and divert the mind, and offers the greatest facilities for observation—it is always available, and has the virtue of costing nothing. Walking, to accomplish its full purpose, should be a free, unrestrained exertion of the powers of locomotion, and should have an object in view. In walking, the form should be erect, the arms and chest should be unrestrained, and allowed that free use which nature designed them to enjoy, and every part of the dress should be loose and easy.

COLLECTING SPECIMENS.

87. Collecting specimens of natural history is admirably adapted to interest the young, and afford an object for walking that is both exciting and ennobling. Plants, insects, birds, minerals, and shells, when we are once initiated into their beauties, are highly interesting objects of investigation and thought, and no pursuit is better adapted to expand and exalt the powers of the mind than the study of nature, as seen in the forest, in the open field, in the quarry, or on the beach.

TIME FOR EXERCISE.

88. The best time for exercise and recreation is in the morning or early part of the day, when the air is pure and invigorat-

ing, and the powers of the body not exhausted by fatigue or excitement. The morning is also the best time for study; and many students indulge in the feeling, that the early part of the day is too valuable to be lost in exercise; therefore they wholly neglect morning exercise, or defer it till the mind has become fatigued, and the nervous system so far exhausted as to impart but little energy to the muscles. Under such circumstances, exercise very soon becomes a drudgery, and fails to impart health and vigor to the system. Exercise immediately before meals, to the extent of inducing fatigue, instead of improving the appetite, exhausts the nervous energy, and unfits the digestive organs for the reception of food. The most appropriate hours for students are soon after breakfast, and an hour or two before twilight. Invalids should avoid the dampness of the early morning and evening, and in summer the heat of mid-day, and select that portion of the day at each particular season of the year when the temperature will be the mildest and the most agreeable. In the early spring, the afternoon, though regarded as the most pleasant, is often the most objectionable part of the day, from the fact that the air is saturated with vapor, and the liability to contract colds is greatly increased thereby.

USE OF THE EYES.

89. The organ of vision is more delicately constructed, and contributes more to our happiness than any other organ of the senses. It is equally true that the eyes are more abused than any other organ.

90. The eye is formed for the special purpose of receiving and transmitting to the brain impressions of the form, size, and color of the various objects with which we are surrounded. It is adapted to viewing objects at a distance as well as to minute inspection of those objects which may be brought near. But long-continued inspection of small objects, however near, is always at the risk of fatiguing this organ, and there is probably no organ of the body which oftener suffers for want of rest than this.

ARTIFICIAL LIGHT.

91. Artificial light, as produced by candles, oil, burning fluid, or gas, is more liable to injure the eyes than the natural light of the sun. It is well known that the properties of natural and artifical light are not the same.

92. Artificial light, however produced, is deficient in the green and blue rays which are most congenial to the eye, and abound in yellow and red rays, which are most unwelcome colors to the eye. It has been found by experience that the eyes are more liable to be injured by artificial light in the morning than in the evening. Very few persons have ever persisted in the habit of early morning study without ultimately injuring the eyes.

93. In using an artificial light, it is of great importance that the position should be such that the light does not shine directly into the eyes, for the direct rays are much more irritating than those which are reflected from the objects on which the eyes rest. The back may be turned to the light, or the light may be placed high enough to have its rays fall on the eyelids, or the eyes may be protected by a screen.

TWILIGHT.

94. The eyes are often injured by using them at twilight. The transition from daylight to dark is usually so gradual, that in studying or reading at this hour the light becomes insufficient before we are aware of it, and the eyes are strained and permanently injured in an attempt to see without a proper amount of light.

95. The eyes should always be permitted a short season of rest from daylight to dark or to artificial light, because the eyes require a little time to accommodate themselves to the change of light, just as in passing from open daylight into a dark room, we can scarcely distinguish a single object at first; but if we wait till the eyes have accommodated themselves to the change, we can see very well; but when we return to the light again, it is

nearly as difficult to distinguish objects as before. In either case, the transition is more or less painful, and would prove highly injurious if often repeated.

WEAK EYES.

96. Weak eyes are a great affliction, and they are the most difficult of all the organs to restore to health. It is, therefore, of the highest importance that any weakness or symptoms of disease of the eyes should receive immediate attention. As soon as there are any indications of disease of the eye, it should enjoy perfect rest till it is fully restored. Any attempt to read, study, or apply the eye, is absolutely certain to increase the difficulty. The use of the eyes by artificial light should be avoided till they are perfectly well and strong. The author has known repeated instances in which a return of disease has been produced by reading in the evening.

RULES FOR USING THE EYES.

97. 1st. Avoid long application to minute objects, and rest whenever the eyes begin to smart or ache.

98. 2d. Use the daylight, and avoid a long continued use of artificial light.

99. 3d. Let the eyes rest during twilight.

100. 4th. In studying or reading, do not allow the light to shine directly into the eyes.

101. 5th. When the eyes become weak, give them rest.

BATHING.

ANTIQUITY OF BATHING.

102. The practice of bathing is of great antiquity, and has been resorted to in every stage of society for the purposes of cleanliness and health, or as a recreation and luxury. The ancient Hebrews, Greeks, and Romans all practised ablutions. Among the Persians, Arabs and Hindoos, baths were employed as a means of cleanliness and recreation at a very early period. The bathing establishments of the Romans were constructed with sur-

passing elegance and splendor, and at an immense cost to the public treasury. When they were in their highest perfection, it is supposed that eighteen thousand persons might have been bathing at once, and been provided with all the varieties of the cold, hot, tepid and vapor baths. When Alexandria was plundered in 640, there were no less than four thousand public baths, which were supposed to have been constructed in imitation of those at Rome. At the present day, the vapor-bath in Russia is general, from the emperor to the lowest serf; and there is hardly a hut in all the dominions of the autocrat that is so destitute as not to possess its family vapor-bath. In Turkey, Egypt and Persia, the habit of resorting to the bath as a luxury is general, from the pacha down to the poor camel-driver. In fact, all the nations of Continental Europe and many of the uncivilized tribes of Asia, greatly excel the otherwise more refined English and Americans in their establishments for securing personal cleanliness. As a people, it must be confessed, that the Americans are proverbial for their neglect of personal cleanliness. Most of our cities have no public establishments for bathing, adequate to meet the wants of the masses; and a great majority of our public houses, though amply provided with every thing else desirable, are wholly destitute of means for furnishing their guests with the convenience and luxury of a bath. Still, it cannot be denied that the utility of bathing, as a means of promoting health, has been most abundantly established by various nations in all ages of the world, and in every variety of climate; and it may well be asked, why should the people of the United States deprive themselves of a luxury so highly conducive to health and happiness?

ADVANTAGES OF BATHING.

103. Habits of uncleanliness are not unfrequently the incipient cause of serious disease of the vital organs. The natural excretions, together with the exfoliations of the scarf-skin, form a coating of foreign matter over the entire surface of the skin, and effectually close up its pores and obstruct its appropriate functions. This thin pellicle of animal impurities not only confines within the system substances which are actually poisonous,

but becomes itself the seat of detention of foreign impurities which here find a resting-place till they are absorbed into the system.

104. Ablution is therefore a necessity—not a mere luxury, which may be indulged in or omitted at pleasure. Persons may occasionally live in total neglect of this, as of other means of promoting health, and yet escape disease for a time; but an impure skin will, in the end, be found incompatible with uniform and lasting health.

105. Aside from the absolute necessity of water as a purifier of the skin, all persons esteem it as grateful and refreshing when applied to the hands and face, and, in those accustomed to its use, it is equally refreshing to the whole body. The oriental custom of offering water for washing, as the first act of hospitality to the weary traveller, is worthy of our admiration. Even food to the hungry is scarcely more refreshing than the bathing of the wearied limbs with water. When applied to the skin, it produces an instantaneous contraction of the capillary vessels, forcing out their contents, and admitting a new supply of blood. An impulse is thus given to the whole circulation, while new tone and vigor is imparted to the capillary and nervous systems. Water to the skin is thus one of the best of tonics. It relieves internal congestion, calms mental excitement, quiets nervous irritability, carries off feverish heat when it exists, and equalizes the circulation.

106. When we consider the uses of water to the person alone, it is not strange that, in an age "when man drew his luxuries more from nature and less from works of his own—when water was his friend more than his servant—water was regarded as a representation of the Deity, and was raised to the dignity of a mythological god. Thus the rivers of Greece and Rome were represented allegorically by a tutelar god with his attendant nymphs, and to this day the Ganges is adored by the votaries of Brahma. Baths were dedicated by the ancients to the divinities of medicine, strength, and wisdom—namely, Æsculapius, Hercules, and Minerva, to whom might properly be added the

goddess of health, Hygeia. The use of water has been adopted as one of the symbols of Christianity."

DIFFERENT KINDS OF BATHS.

107. Water is applied to the skin in a variety of ways, according to the fancy and convenience of each individual, and according to the purpose to be accomplished by its use—by immersion, a plunge, a douche, or a shower. The most simple and natural division of baths, in regard to temperature, is into cold, warm, and hot. These terms, so far as our sensations are concerned, are merely relative, and cannot be fixed uniformly at the same temperature.

108. Water of eighty degrees would produce a sensation of pleasant and agreeable warmth to the hand immediately after exposure to a lower temperature; but if applied to the body at the same temperature, it would produce a decided impression of cold. We can therefore assign only certain general limits to each kind of a bath. A full bath, under eighty-four degrees would be regarded as cold by most persons; from eighty-four to ninety-two, tepid; from ninety-two to ninety-eight, warm. Most persons, under ordinary circumstances, will assent to the following divisions—namely: for the cold bath, under eighty-four; for the tepid, from eighty-four to ninety-two; for the warm bath, from ninety-two to ninety-eight; and for the hot bath, any temperature over ninety-eight degrees. A medium temperature for the tepid bath will then be eighty-eight, and for the warm ninety-five degrees.

COLD BATH.

109. The cold bath is usually taken at about the same temperature as the air of the apartment, and may be applied either by a *plunge*, a *douche*, or with a *sponge*.

PLUNGE BATH.

110. The plunge bath is very agreeable in a warm apartment or in the open stream in warm weather, and affords a high-

ly useful means of cleanliness, recreation and exercise, when accompanied with swimming, or when followed by liberal friction. Swimming for most persons, is a very agreeable and active exercise, and a valuable accomplishment for all. In the act of swimming, the respiration is accelerated, and nearly all the muscles of the body are brought into active exercise, and the capacity to evolve animal heat greatly increased. Persons who swim or take active exercise in the bath, resist the operations of the cold, and experience a salutary reaction and glow, much better than those who are inactive.

THE DOUCHE.

111. The douche, which consists in pouring a large stream of water on the whole person, or on a particular part, is useful mainly when it is desirable to gain a decided shock, and is usually applied only to a particular part.

SHOWER-BATH.

112. The shower-bath admits of considerable variety, both in its application and its effects. It may be applied gently in small streams, or with great force and in large streams. Many of the portable shower-baths, as offered in the shops, contain large apertures, which allow the water to fall in torrents, and few persons have the courage or ability to endure the force, it being more like a hail-storm than a gentle, refreshing shower. The shower-bath should be so constructed that the streams shall be small, and easily controlled at the pleasure of the bather. When properly conducted, we can testify from our own experience that the shower-bath is a most delightful means of promoting health. It gives a general shock to the whole system, and is followed by a grateful glow of warmth and a general activity of the circulation. For those who can bear it, the shower-bath is to be preferred to all other forms of cold bathing. The quantity and force of the water should be under the control of the bather, and the apartment should be so arranged that the whole, or only a part of the person should be exposed at pleasure. The sponge-

bath is to be recommended for its convenience and universal presence. It can always be enjoyed at home and abroad, and when faithfully applied it is a highly salutary and agreeable bath.

EFFECTS OF COLD BATHING.

113. On the application of cold water to the surface of the body, by either of the above methods, the skin immediately shrinks, and the whole of the tissues contract, diminishing the diameter of the cutaneous vessels and their capacity for blood. A portion of the blood circulating near the surface is thus suddenly thrown in on the deeper parts, and especially on the internal organs. This sudden change in the order of things stimulates the nervous system, and thus rouses the heart to more energetic action to relieve the internal organs by sending back the blood to the surface. As the warm blood comes rushing back to the surface, a general glow of warmth is experienced throughout the whole system. There is a general redness of the surface, the mental faculties are clear and strong, the senses are acutely alive to all external impressions, the appetite is sharpened, and the whole organism invigorated. This highly desirable state is what is called a *healthy reaction*. When this does not take place, the surface becomes cold and bloodless, the heart and circulation languid, and the mental faculties dull and depressed. Under such circumstances, the associations connected with the bath are disagreeable and forbidding. With a proper reaction, nothing can be more refreshing and grateful to the feelings than a generous bath. Without it, nothing is more unwelcome or more to be dreaded. In one case, the cold bath is a highly useful means of promoting health; and in the other, it is as decidedly pernicious. The aged, the invalid, and the bloodless, who have not sufficient vigor to secure a healthy rëaction, cannot resort to the cold bath with impunity. But with the opposite and more fortunate class, it is not only a luxury, but a most valuable means of invigorating the health and strengthening the constitution to bear with impunity exposure to cold and sudden changes of temperature. For the most part, those persons who

practise daily ablution in cold water, are but seldom subject to colds and fevers, and when they are, they recover much sooner than others. The ability to practise cold bathing is in part the result of training. The bather at first uses tepid water, and gradually becomes accustomed to a lower temperature, till the cold bath comes to be preferred to any other. The uninitiated should therefore commence with water at an agreeable temperature, and gradually diminish it till they can bear the water at the same temperature as the surrounding air.

TEPID BATH.

114. In the tepid bath, the shock is milder than in the cold, and the reaction less marked. It is therefore to be preferred by those who have not sufficient vigor to endure cold bathing. The precise temperature of the tepid bath may be regulated according to the feelings of the patient.

TIME FOR COLD BATH.

115. The best time for the cold or tepid bath is early in the morning or about an hour before dinner. Persons in health will usually prefer the bath immediately after rising in the morning, since it occupies less time than at any other hour. Invalids and persons of leisure will find the bath more agreeable three or four hours after breakfast. Bathing immediately after taking a full meal interferes with the process of digestion, and has a tendency to divert a portion of the nervous energy from this process, while the nervous and vascular excitement which constitutes a healthy reaction, is less perfect than where digestion is completed. The capacity for a healthy reaction is also diminished by mental or bodily fatigue, to an extent that renders the cold bath wholly unsafe after the body has become weary by labor, or the nervous system depressed by mental effort. Mental excitement, an evening debauch, and unusual fatigue, are circumstances which render the cold bath improper on the following morning, even though the individual may have been in the habit of using it daily. When the circulation is languid and the skin cool, or

when there is any unusual depression of the vital energies, the cold bath ought to be postponed.

DURATION OF COLD BATH.

116. The duration of the cold bath should not be over ten minutes, unless it is accompanied by swimming or active exercise, when it may be continued as long as it is found to be pleasant and agreeable. Invalids and persons whose capacity for reaction is feeble, should not spend more than two or three minutes in the bath, and they should then be enveloped in a warm blanket, or speedily dressed in warm clothing.

WARM BATH.

117. The warm bath has a soothing, tranquillizing effect on the whole system. It quiets the circulation and calms all nervous excitement, by equalizing the circulating fluids and producing a general equilibrium. The bather experiences a most delightful consciousness of comfort and well-being, and an inclination to repose, without any feeling of inability for mental or bodily exercise. The warm bath is specially grateful to the weary and fatigued, and is an efficient means for the relief of internal inflammations, congestions, fevers, and colds. For children that are nervous and irritable, from teething or other causes, the warm bath is one of the best anodynes that can be administered. It diminishes the animal heat, calms the nervous excitement, and disposes to quiet, refreshing sleep. The hot bath acts as a stimulant, communicating heat to the body, increasing the heart's action, and producing a high degree of nervous excitement. If it be continued for any great length of time, it is followed by a feeling of prostration, amounting to fainting, and even apoplexy, when the bath is indulged too long. The hot bath is useful chiefly when a decided impression on the circulation and the nervous system is desired.

VAPOR BATH.

118. The vapor bath does not differ essentially from the warm bath in its physiological effects. It stimulates the cutaneous circulation, determines the blood to the surface, and causes an increased activity of the functions of the skin. When the skin is dry and harsh, the vapor-bath is to be preferred to all others, since it softens the cuticle, and produces exfoliation more perfectly than any other. It is a very valuable means for the relief of colds and inflammations, and is a great luxury to the weary and fatigued. It equalizes the circulation, and is highly refreshing and invigorating. From the increased activity it imparts to the cutaneous vessels, immediate exposure after its use is less liable to be followed by colds than after the warm bath by immersion.

TRANSITION BATH.

119. *Transition* baths are those in which there is a quick passage from a warm or hot to a cold medium, whether vapor or water. In the Russian bath, the bather enters a warm room, filled with vapor produced by pouring water over red-hot stones, and remains till the body is in a profuse perspiration, and then rushes forth to roll in the snow or plunge into the nearest stream. When neither is accessible, he cools himself by affusions of cold water, pouring over his head a bucketful at a time. The heat of the bath is seldom less than one hundred and twenty degrees Fahrenheit, and is often as high as one hundred and forty. The transition baths of the ancient Romans must have been nearly the same in effect as the Russians of the present day. These abrupt transitions of temperature may seem almost in credible to those who have fallen into the error of supposing that the liability to contract colds is increased by the warm bath. The fact, however, is, that the power of resisting cold becomes greater in proportion as the animal heat is above the natural standard. After exposure to the intense heat of the high temperature of the Russian bath, there is a state of nervous and vascular excitement and a degree of animal heat which enables the

bather to bear with impunity the sudden application of cold, and part with an amount of heat which, under other circumstances, could not fail to be injurious. When the application of cold is carried just far enough to reduce the animal heat to a medium temperature, the effect on the system is most salutary and delightful. The previous excitement is now followed by a most grateful calm, the pulse is restored to the equilibrium of health, the mind is clear and active, and every part of the body refreshed and invigorated. As a relief to a cold, or the premonitory symptoms of a fever, the efficacy of the warm bath is unquestionably increased by a sponge, a shower, or a douche. Under any circumstances, most persons will find the warm bath more agreeable and more useful, when the excitement and the animal heat derived from the bath are relieved by the application of cold water; though it is very doubtful whether the high temperature of the Russian bath is not exhausting to the system, if often repeated, notwithstanding the transition to the cold bath so soon restores the equilibrium of animal heat. But a bath at about blood-heat, followed by a cold showering or sponging, is free from this objection; and while it is certainly very grateful to the feelings, it is also highly salutary as a means of promoting health, as the author can testify from personal experience.

TIME OF DURATION OF WARM BATH.

120. The warm or vapor bath may be taken at almost any hour of the day, except after a full meal, though the hour before retiring to bed is usually preferred, on account of there being less subsequent exposure at that hour than at any other. A much longer time may be spent in the warm bath than in the cold—from fifteen to thirty or even forty minutes, according to the feelings and constitution of the individual.

REPETITION OF BATHING.

121. The frequency of bathing is to be determined by the age, constitution, and habits of life of the individual. The aged, in whom the vital functions are less active, and the vital

powers less vigorous, will find two or three times a week often enough to resort to the bath for the purposes of health. Children should be bathed daily, the first year with warm, during the second with tepid, and subsequently with cold water. The practice of bathing infants in cold water is attended with very great risk. Children that are remarkably protected by flesh, or who have inherited hardy constitutions, may endure the exposure with impunity; but for the slender and feeble it will, in a majority of cases, prove decidedly pernicious, if not fatal to life. For the purposes of health and cleanliness, the warm bath need not be resorted to oftener than two or three times a-week by adults. Persons in full health ought to practise bathing every morning on rising from the bed, as part of the duties of the toilet. Daily ablution contributes not only to personal comfort, but it is a most salutary means of fortifying the system against colds, fevers, and many diseases to which we are otherwise exposed. There is a very close sympathy between the skin and the nervous membrane of the alimentary canal; and those who preserve the skin in a clean, healthy and vigorous condition, will find themselves abundantly rewarded by exemption from many gastric and intestinal complaints to which others are liable.

CLOTHING.

122. Dress does not make the man, but it is often indicative of his character. Some men dress in such a manner as to indicate that they estimate themselves by the cost per yard of the garments they wear. Others dress so as to convey an impression of perfect indifference to the feelings and sentiments of those around them. Both are wrong. Our personal appearance, which depends to a great extent on dress, is a matter of some consequence—and the man who wholly disregards the customs and habits of others, in this respect, will be very likely to be indifferent to the sentiments and feelings of society in other particulars, and at least may be in danger of passing for less than his true worth. But the fop, whose only accomplishment is the dress he wears, is usually despised as thoughtless and vain.

123. The style of dress which is most to be commended, is that which will not attract attention either for its gaudiness or its plainness. The external appearance of our clothing should always be regarded less important than its practical uses, inasmuch as bodily health is infinitely more important than personal appearance.

SUMMER CLOTHING.

124. During the warm season we require clothing which will protect the body without retaining too large an amount of heat. For this purpose, we prefer in summer materials which are good conductors of heat. Linen is a good conductor of heat, and therefore furnishes the most agreeable material for extreme warm weather. Cotton and worsted, though not as good conductors as linen, are usually found sufficiently cool for the temperature of the northern States, where the climate is so changeable that there are but few days in the season when linen can be worn with safety.

WINTER CLOTHING.

125. Winter clothing should correspond somewhat with the exposure both in quality and amount. The object to be sought in winter clothing is, not to produce heat, but to retain the heat which the body is constantly evolving. If a dead man were enveloped in ever so many clothes, he would not become warm thereby—though he might retain for a longer period the warmth he already possessed. Those materials which are the poorest conductors of heat will retain the heat of the body longest, and are therefore to be preferred.

126. Woollen is one of our best non-conductors of heat, and all garments formed from this material are regarded as warm clothing. Silk is not as good a non-conductor as woollen, though better than cotton. All kinds of furs are good non-conductors, but they are liable to two very serious objections: 1st. Furs are too warm for ordinary exposure, and cause too great a change of temperature when they are removed. 2d. Fur garments are objectionable because they prevent the escape of the perspiration,

and confine it within the garments usually worn inside of the fur Both these circumstances tend to render those who wear furs more liable to colds than those who wear only woollen or silken garments.

AMOUNT OF CLOTHING.

127. The amount of clothing should depend on the constitutional vigor and the exposure of each individual.

128. The greatest amount of clothing is required in infancy and old age. The power of resisting cold is less in those extremes of life than during any of the intervening periods of life. Invalids and persons of sedentary habits require warmer clothing than the vigorous and active.

129. The amount of clothing should also depend in part on the exposure. In-doors we require less than during an out-door exposure,—less when taking active exercise than when inactive. We suffer more during the winter months from the frequent changes of temperature than from the long continuance of cold. The amount of clothing, therefore, should be sufficient to insure a constant and uniform protection against sudden changes. And it is better to wear more clothing than we absolutely require, when the weather is mild and pleasant, than to be unguardedly exposed to cold.

130. Those who are accustomed to spend most of their time in-doors should put on extra garments for out-door exposure, except when walking or taking active exercise. The habit of "*bundling up*," as it is called, with an unnecessary amount of clothing, is injurious for two reasons. It produces too much warmth, and prevents that healthy reaction on exposure which is conducive to vigorous health. It is especially injurious to bundle up the face and neck with fur collars and shawls, which are so warm that colds will be contracted when they are removed.

UNDER GARMENTS.

131. Most physicians recommend, in a changeable climate, the constant wearing of flannel or silken under garments next to

the skin. They absorb the perspiration, and preserve a uniform temperature of the surface of the body, and prevent that sense of chilliness which we are very liable to experience without flannels. During summer, however, these garments may be thinner than in winter.

FORM AND SIZE OF GARMENTS.

132. The form and size of our garments is a matter of some importance, since the human form is of infinitely more consequence than the garment which is designed to cover and protect it. All the garments of both sexes should be made free and easy, and not "*snug fits.*" Garments that are loose may be graceful and becoming, as well as better adapted to the full and perfect development of the form. Tight garments compress the vital organs, interfere with free muscular exercise, confine the perspiration, and are not so warm as those which permit a space of air between the body and the clothes, as any one can testify who has made the experiment of wearing tight boots on a cold day.

FASHION OF GARMENTS.

133. The folly of following fashions in dress is at no period more marked by its legitimate results, than in the practice too common among Americans, of dressing infants and small children with the neck and arms bare and unprotected. The fearful mortality among children in our cities during the winter months, is abundant proof that cold annually sends a large number to an early grave. That the susceptibility to cold must be much greater when a considerable portion of the body is entirely naked, is very evident. If we regard anatomical structure, there is no portion of the body that might not be unclothed with equal propriety. In the arms all the principal blood-vessels are near the surface, and have no natural protection against the cold, as in the face, where the vessels are small and deep-seated. It is well known that we usually experience the effects of cold in the extremities first, and that, in riding, men seldom suffer from cold so long as the hands and feet are kept warm.

134. If we lose sight of the anatomical limits of the neck, and describe it as extending from the head to the top of a fashionable dress, the reasons for its protection will be very obvious, when we consider, that in this space are located the larynx, trachea, bronchial tubes and the upper portion of the lungs, organs on which croup, bronchitis, and lung fever—which constitute a very large share of the diseases of winter—have their location, and are caused in thousands of instances by want of proper clothing. A blind devotion to fashion among children and females thus often proves a most reckless sacrifice of health and life.

BLEEDING.

135. Bleeding may take place as the result of an injury, or it may occur spontaneously from some one of the internal organs.

136. In case of an injury, it is important to consider whether the bleeding is from an artery or a vein. If the bleeding is from an artery, it may be known by the bright scarlet color of the blood, and from its issuing in jets. When the bleeding is from a vein, it is a dark purple color, and flows continuously. The bleeding from a vein may be very profuse at first, and soon subside of its own accord. Arterial bleeding is more liable to continue till it is arrested by artificial means.

137. To stop arterial bleeding, a surgeon will usually be required to take up and tie the divided artery. In the absence of a surgeon, the bleeding may be arrested by putting the finger in the wound and pressing on the bleeding aperture. If the bleeding is from either of the extremities, you may find the position of the artery above the injury, and press on it with your thumb or finger till the bleeding is controlled, or you may fold a piece of rag several times, and placing it over the artery, tie a handkerchief twice around the limb, and the compress thus made, and twist the handkerchief with a stick, till the pressure is sufficient to produce the desired result. In bleeding from a vein, a small fold of cloth, bound firmly upon the wound, will usually be found sufficient.

QUESTIONS TO APPENDIX.

THE AIR WE BREATHE.

1. What is the height of the air around the earth? What is its pressure on every square inch of the earth's surface? 2. What are the constituents of the air? 3. What is oxygen? When it combines rapidly with any substance, what does it produce? 4. What effect does it have on animals to breathe pure oxygen? How is man dependent on oxygen? How does it affect the blood? 5. How does oxygen affect the respiration and circulation?

6. For what is nitrogen useful? Does it support combustion or animal life? Why not?

7. What is carbonic acid? 8. What are the effects of breathing one per cent. of carbonic acid?—three or four?—six or seven? ten? How are persons affected who confine themselves in apartments containing only a small excess of carbonic acid? How does it increase the liability to consumption? 9. How is carbonic acid formed? What per cent. of the respired air is carbonic acid? How much per day? 10. How much carbonic acid escapes from the skin daily? What remarkable fact? 11. How much watery vapor is the respired air found to contain? Is this vapor pure water? What causes the fetid odor in the breath of some persons? What increases this odor?

12. What is said of the natural excretions of the skin?—of the amount of impurities which pass off from it? What is a general estimate of the amount of the daily excretions of an adult? What are the excretions composed of? What causes the peculiar odor of perspiration? 13. Give the total quantity of impurities which are daily given off by an adult. According to Dr. Lee, how much air does each person render unfit for respiration every minute?

VENTILATION.

14. What is said of ignorance in regard to ventilation? 15. What is the effect of breathing impure air? What is the condition of air which has been breathed over and over again in our parlors, school-rooms, &c.? 16. What is a common cause of typhus fever? Where do typhus fever, dysentery and the cholera take their origin? What is indicated by the countenance in the spring?

17. What heating apparatus was used till within the last half century? What is said of it? 18. What is said of an open fire as a ventilator? What objection to an open fire? 19. How does an open fire compare with an airtight stove? 20. What is said of hot-air furnaces and ventilating stoves? Is this system of heating perfect? Why not? 21. What is the temperature of air as it is delivered from most hot-air furnaces? How may this objection be obviated? 22. What method of ventilation is the best? 23. Repeat the rules for ventilation.

DIET.

30. How does man differ from other animals in regard to diet? How are other animals directed in the selection of food? How is man endowed? How should he select his food? 31. What circumstances should influence the choice of food? 32. How do the constituent elements of the body vary at different periods of life? What predominates in middle life?—in the child? What is the condition in the aged?

33. What dissimilarity exists in different individuals of the same age? To what should each person adapt his diet? 34. What do the inhabitants of cold climates require? On what do the inhabitants of tropical climates subsist? 35. What modification of food is required in temperate climates? What would be the effect of indulging in summer in a diet which might be appropriate in winter? What should each person possess? 36. In what proportion are different substances nutritious? From what source do animals derive the elements of their growth? On what does the nutritive value of different substances depend?

37. What is said of milk? 38. What elements does milk contain? 39. What is said of fish?—of salmon and eels, and of haddock, sole, flounder, cod and turbot? 40. How is the digestibility of fish diminished? When may a fish diet be employed? At what season of the year

is fish best adapted to the wants of the body? 41. What is said of oysters? 42. When are fish and oysters unsafe articles of diet? 43. What is said of lobsters?

44. What is said of meat? 45. Which are most digestible, young meats or old? 46. How does the vegetable kingdom compare with the animal in the number and variety of its aliments? What are the nutritive principles in vegetables? 47. What essential elements are to be found in abundance in vegetables? What examples of animals that live exclusively on animal—and on vegetable food? What variation in the digestive organs of the two classes? What is man in structure and habits? 48. What instances are given of an exclusive diet of each? 49. What is the universal preference of mankind?

50. What is said of ripe fruits? How are they regarded by most city physicians? Under what circumstances are fruits dangerous? Of what are the injurious results the consequence? 51. Under what circumstances may fruit and vegetables be regarded as safe? How are children affected by fruit? What caution should children observe? What is said of orange-peel, and the skins and stones of cherries, plums and grapes?—of cucumbers, beets, green potatoes, and green fruit?

52. Of what importance is water? What per cent. of the blood is water? What portion of the whole body is water? What purposes does water accomplish in the human body? 53. How does water compare with other drinks? 54. Has nature offered any substitute for water? 55. What is the effect of water on fires?

56. What substances are naturally difficult of digestion? What circumstances render the digestive process more easy? How does the flesh of young animals compare with others in digestibility? What circumstance facilitates digestion? 57. How does the art of cooking affect the digestibility of food? 58. What is said of boiling?—59. of roasting? 60. of frying? 61. of pastry?—of different articles compounded together? 63. How does the rapidity of digestion vary according to Dr. Beaumont? 64. What is said of variety of food? 65. Is a great variety at the same meal beneficial? 66. How is the diet of each individual to be determined?

THE TEETH.

65*. To what are good teeth indispensable? What is said of the matter which is constantly exuding from decayed teeth? Whats ubstances collect in the cavities of decayed teeth? 66*. Why do the teeth often

decay so early? 67. How does an accumulation of foreign substances between and around the teeth cause decay? 68. Does the natural use of the teeth cause their decay? 69. Where does decay usually commence? 70. What is the secret of preserving the teeth? 71. How may the teeth be kept clean? 72. What should be done when decay commences?

EXERCISE.

73. What is said of the importance of exercise?—of strength? What is ultimately the condition of those who live without exercise? 74. For what are the muscles designed? How does muscular action affect the blood, and the vital changes which take place in the growth and nutrition of the body? 75. What are the advantages which arise from exercise? 76. Why are the consequences of neglecting exercise not seen and felt immediately? What organ is most likely to become diseased first? 77. How can we secure the greatest benefit from exercise? What exercise will be found most useful? 78. Why should there be a variety of exercise? What will be the condition of the muscles that are not exercised? 79. What do we need besides exercise? How may the laborer or mechanic suffer?—How may the physician suffer? What do all persons require? 80. What is said of manual labor?—of field sports, games, &c.? 81. How is journeying most beneficial? 82. What is said of horseback riding? 83. What are gymnastic exercises? How are the muscles affected by this kind of exercise? 84. What is calisthenics? 85. How should gymnastic or calisthenic exercises be practised at first? What caution is to be observed after taking this kind of exercise? 86. What is said of walking?—How should walking be practised? 87. What are the advantages of collecting specimens for exercise? 88. When is the best time for taking exercise?

USE OF THE EYES.

89. What is said of the organ of vision? 90. For what special purpose is the eye formed? How is it adapted to viewing objects? What objection to long continued application of the eyes to small objects? 91. Why is artificial light more liable to prove injurious to the eyes than daylight?

92. In what rays is artificial light deficient? When are the eyes

most liable to be injured by artificial light? 93. What should be the position of the light? 94. At what hour are the eyes often injured? Why are the eyes more liable to be injured at this hour? 95. Why do the eyes require a short season of rest between daylight and dark? 96. What is said of weak eyes? How are weak eyes to be managed. Repeat rule first—second—third—fourth—fifth.

BATHING.

102. What is said of the antiquity of the practice of bathing? What ancient nations practised ablutions? How were the bathing establishments of the Romans constructed? How do the English and Americans of the present day compare with other nations in their habits of cleanliness? 103. What evils arise from habits of uncleanliness? 104. Is ablution a necessity or a mere luxury that can be dispensed with? 105. What is said of the pleasure of bathing? 106. How was water regarded by the ancients? 107. How is water applied to the skin? 108. What is the temperature of a cold bath?—a tepid bath?—a warm bath? 109. How may a cold bath be applied? 110. What is said of the plunge bath?—of swimming? 111. What is a douche? 112. How may a shower bath be applied? What objection to shower baths as they are often constructed? What are the effects of the shower bath when properly managed? How should the shower be regulated? 113. Describe the effects of the cold bath. When there is not a healthy reaction, what are its effects? What persons are liable to be injured by cold bathing?

On what does the ability to practise cold bathing depend? How should the bather commence at first? 114. What are the effects of the tepid bath? 115. When is the best time for a cold bath? What objection to bathing after a full meal? 116. How long should a cold bath continue? 117. What are the effects of the warm bath? How does the hot bath act? 118. What is a water bath? 119. What is a transition bath? How is it practised in Russia? 120. When may a vapor bath be taken? 121. How is the frequency of bathing to be determined? How often should children be bathed?—persons in full health? What are the advantages of daily bathing?

CLOTHING.

122. What relation has the dress to the character of men? How do different persons dress? On what does our personal appearance

depend? What is the effect of indifference to the customs and habits of others in respect to dress? How is the fop esteemed? 123. What style of dress is most to be commended? What is more important than personal appearance? 124. What kind of clothing do we require during summer? 125. What is the object to be sought in winter clothing? 126. What is said of woollen?—of silk?—of fur? What objections to fur?

127. On what should the amount of clothing depend? 128. When is the greatest amount of clothing required? 129. On what other circumstances should the amount of clothing depend? 130. When is it necessary to put on extra clothing? What is said of the habit of "*bundling up*"? 131. What are the benefits derived from under-garments? 132. Of what importance is the form and size of garments? How should the garments be made? What objections to tight garments? 133. At what period of life is the folly of following fashion most apparent? What are the objections to dressing children with their arms and necks bare?

134. What organs are exposed by wearing low dresses?

BLEEDING.

135. How may bleeding be caused? 136. How may we know whether bleeding is from a vein or an artery? 137. How may arterial bleeding be arrested?

RULES FOR THE PRESERVATION OF HEALTH.

EVERY apartment we occupy should be provided with some efficient means of ventilation, by which the impure gasses may be conducted off, and a constant supply of pure air secured.

The meals should always be taken at uniform intervals, and the appetite not indulged at irregular hours.

The food should be plain and substantial, and not taken in haste or in a passion.

Fruit and vegetables, when fully ripe, are conducive of health, if used in moderate quantities with other food. Berries should be used within twenty-four hours after picking, or they are liable to become highly injurious from the commencement of the process of acetous fermentation.

After dinner there should be at least half an hour's leisure and rest from active labor. Students and men of sedentary habits should take not less than an hour for recreation or gentle exercise.

Children under three years of age enjoy better health without animal food, and from three to seven it should be allowed only in moderate quantities.

The clothing should always be adapted to the season of the year, and as nearly uniform as possible, though the habiliments of winter should not be exchanged for those of summer till the weather becomes permanently warm and mild. By wearing an abundance of warm clothing during winter, less food and less artificial heat are required, and there is less susceptibility to colds from exposure to sudden changes of temperature.

Sleeping apartments should be cool and well ventilated. Hair beds are much better than feathers.

Children of all ages should spend some portion of every day, when not stormy, in the open air.

Children under seven years should not be confined in school more than four hours each day, and that time should be broken by frequent recesses.

Students should train their minds to act with correctness and energy for limited periods of time, and then use a spare diet, with three or four hours daily exercise in the open air, and occasional vacations of complete exemption from study.

Young persons of both sexes, whatever their occupation, should spend at least two hours each day in active exercise in the open air.

Every person in full health should wash all over in cold water every morning.

GLOSSARY AND INDEX.

THE FIGURES REFER TO THE PARAGRAPHS.

A.

ABDO'MEN (L. *abdo*, to hide). So called from its containing the intestines, &c. [89.]

ABDUC'TOR (L. *abduco*, to draw from). *Abducent*. A muscle, whose office is to draw one part of the body away from another.

ABSORP'TION. The act or process of imbibing or swallowing. [31-196.]

ABSORB'ENTS. Vessels which imbibe, as lymphatics and lacteals. [199.]

ALBI'NO. A white descendant of black parents.

ALBU'MEN (L. *albus*, white). Albumen is of two kinds, animal and vegetable: 1. *Animal albumen* exists in two forms, the liquid and the solid. In the *liquid* state, it is a thick glairy fluid, constituting the principal part of the white of egg. In the *solid* state, it is contained in several of the textures of the body, as the cellular membrane, the skin, glands and vessels.—2. *Vegetable albumen* closely resembles animal albumen, and has been found in wheat, rye, barley, peas, and beans. [46.]

AMPHIB'IA. The second class of the Vertebrata, comprising amphibious animals, which commence their larva state as fishes, and undergo various degrees of metamorphoses in advancing towards the condition of reptiles, as the frog, &c. [150.]

AN'IMAL-HEAT. [123.]

ANASTOMO'SIS (Gr. *aná*, through, and *stoma*, a mouth). The communication of vessels with each other, as of the arteries with the veins, which, by touching at numerous points, form a net-work or reticulation. See *Inosculation*.

ANAT'OMY (Gr. *anatémnō*, to cut up). The science of organization; the science whose object is the examination of the organs or *instruments* of life. Animal anatomy is divided into *human anatomy* and *comparative anatomy*, according as it treats of the organization of the human body, or of that of other animals. [9.]

AN'TENNÆ. The horns or feelers of insects.

AOR'TA (Gr. *aèr*, air, *teréō*, to keep; as having been formerly supposed to contain only air.) The great artery of the heart. It is distinguished into the *ascending* and *descending*. [65.]

AQ'UEOUS. Watery.

ARACH'NOID MEM'BRANE (Gr. *arachnē*, a spider, and *eīdos*, likeness). The fine *cobweb-like* membrane situated between the dura and pia mater. It is the serous membrane of the cerebro-spinal centres. [299.]

AR′BOR VI′TÆ. Literally, *tree of life.* A term applied to the *arborescent* appearance presented by the cerebellum, when cut into vertically. [298.]

AR′TERY (Gr. *aër*, air, and *teréō*, to hold). A vessel which carries the blood from the heart; formerly supposed, from its being found empty after death, to contain only air.

ARYT′ÆNOID (Gr. *árútaina*, a ewer, and *eīdos*, likeness). A term applied to two triangular cartilages of the larynx. [478.]

AU′DITORY (L. *audio*, to hear). Belonging to parts connected with the sense of hearing. [359.]

AURIC′ULA (L. dim of *auris*, the ear). An auricle; the prominent part of the ear. Also, the name of two cavities of the heart. [57.]

AUTOMAT′IC MOTIONS (Gr. *automatos*, of his own accord). Those muscular actions which are not dependent on the mind.

AUTOM′ATON. A self-moving machine.

B

BALL-AND-SOCK′ET. A species of movable articulation, as that of the hip.

BICUSPIDA′TI (L. *cuspis*, a spear). Having two tubercles; as applied to the two first pairs of grinders in each jaw.

BI′LIS. Bile, gall, or choler; the secretion of the liver. [63.]

BIL′IOUS. A term employed to characterize a class of diseases caused by a too copious secretion of bile.

BI′VALVE. An animal having two valves.

BRAIN. [295.]—Of a fish. [282.]—Of a bird. [283.]

BRONCH′US (Gr. *bróngchos*, the windpipe, from *bréchō*, to moisten). The windpipe; a ramification of the trachea; so called from the ancient belief that the solids were conveyed into the stomach by the œsophagus, and the fluids by the bronchia. [100.]

BRONCH′IAL-TUBES. The minute ramifications of the bronchi, terminating in the *bronchial cells*, or air cells of the lungs.

BRONCHI′TIS. Inflammation of the bronchi, or ramifications of the trachea.

BUR′SÆ MUCO′SÆ (*mucous bags*). Small sacs situated about the joints, being parts of the sheaths of tendons.

C

CÆ′CUM, or CŒ′CUM (L. *cæcus*, blind). The first part of the colon, or *blind* intestine.

CAL′LUS (Latin, *hardness*). New bone, or the substance which serves to join together the ends of a fracture, and to restore destroyed portions of bone.

CAN′CER. Literally, a *crab*. The term is applied to the disease from the claw-like spreading of the veins.

CANINE′-TEETH (L. *canis*, a dog). Eye-teeth; the four immediately adjoining the incisors. [143.]

CAP′ILLARY (L. *capillus*, a hair). Resembling a hair in size; a term applied to the *vessels* which intervene between the minute arteries and veins.

CAPSU′LA (L. dim. of *capsa*, a chest). Literally, a little chest A capsule or bag, which incloses any part. [144.]

Car′bon (L. *carbo*, a coal). A substance well known under the form of coal, charcoal, lamp-black, &c. In chemical language, it denotes the pure inflammable principle of charcoal; in its state of absolute purity, it constitutes the *diamond*.

Carbon′ic Acid. Carbon and oxygen combined. [12–114.]

Car′dia (Gr. *kardia*, the heart). The entrance into the stomach, so called from being near the heart. [159.]

Car′diac (Gr. *kardia*, the heart). Relating to the heart.

Carniv′orous (L. *caro-voro*). Eating flesh.

Carot′id (Gr. *karóō*, to induce sleep). The name of two large arteries of the neck; so called from an idea that tying them would induce stupor.

Car′pus (Gr. *karpós*, fruit). The wrist. The *ossa carpi*, or carpal bones, are eight in number, and form two rows. [444.]

Car′tilage. Gristle. It is attached to bones, and must be distinguished from the ligaments of joints and tendons of muscles. [88.]

Cau′da Equi′na, or horse's tail; the final division of the spinal cord; so called from the disposition of the nerves which issue from it.

Cerebel′lum (dim. of *cerebrum*). The little brain, situated behind the larger, or cerebrum. [295.]

Cer′ebrum (Gr. *káre*, the head). The brain; the chief portion of the brain, occupying the whole upper cavity of the skull. [281.]

Cer′ebro-spinal. System. [285.]

Cer′vix. The neck; the hinder part of the neck: the fore part is called *collum*.

Chest. *Thorax*. An old English term, commonly traced to the Latin *cista*.—"When it is considered that the same word was anciently used for a *basket*, the appropriation of it to the human thorax will appear quite natural to any one who has ever seen a skeleton."—*Forbes*. [102.]

Chyle (Gr. *chulòs*, juice). The milk-like fluid absorbed by the lacteal vessels. [22.]

Chylifica′tion (L. *fio*, to become). The process by which the chyle is separated from the chyme.

Chyme (Gr. *chumòs*, juice). The semi-fluid matter which passes from the stomach into the duodenum. [22–175.]

Chymifica′tion (L. *fio*, to become). The process by which the aliment is converted into chyme.

Cil′iary (L. *cilia*, eyelashes). Belonging to the eyelids. [371.]

Cil′iary Cir′cle or Lig′ament. A kind of grayish ring, situated between the choroid membrane, the iris, and the sclerotica.

Cil′iary Pro′cesses. Small membranous bodies, surrounding the crystalline lens in a radiating form.

Cineri′tious (L. *cineres*, ashes). Ash-colored; a term applied to the exterior or cortical part of the brain,

Clavic′ula (dim. of *clavis*, a key). The clavicle, or collar-bone; so called from its resemblance to an ancient key. [442.]

COC'CYX (Gr. *kókkux*, a cuckoo). The lower end of the spine; so called from its resemblance to the cuckoo's beak. [426.]

COCH'LEA (Gr. *kóchlos*, a conch). A cavity of the ear, resembling the spiral shell of the snail. [358.]

CO'LON (Gr. *kolōn*, quasi *koīlon*, hollow). The first of the large intestines, commencing at the cœcum, and terminating at the rectum. [185.]

CO'MA (Gr. *kōma*, drowsiness, from *kéō*, to lie). Drowsiness; lethargic sleep; dead sleep; torpor.

COM'MISSURE (L. *commissura*). To joint or sever the place where two bodies or parts of a body meet and unite.

CON'DYLE (Gr. *kóndulos*, a knuckle). A rounded eminence in the joints of several bones, as of the humerus and the femur. [447.]

CON'GESTION (L. *congero*. to amass). Undue fullness of the blood-vessels.

CONJUNC'TIVA (L. *conjungo*, to unite). The mucous membrane which lines the posterior surface of the eyelids, and is continued over the fore-part of the globe of the eye. [374.]

COR'ACOÏD PRO'CESS (Gr. *kórax*, a crow, and *eīdos*, likeness). The upper and anterior point of the scapula; so called from its resemblance to a crow's beak.

CO'RIUM. Leather. The deep layer of cutis, or true skin, forming the basis of the support to the skin.

CORN'EA (L. *cornu*, a horn). The anterior transparent portion of the globe of the eye. [376.]

CORPUS'CULUM (L. dim. of *corpus*, a body). A corpuscle, or little body.

CRA'NIUM (Gr. *kára*, the head). The skull, or cavity which contains the brain, its membranes, and vessels. [295.]

CRIB'RIFORM (L. *cribrum*, a sieve, and *forma*, likeness). The name of the plate of the ethmoïd-bone, from its being perforated like a sieve.

CRI'COS (Gr. *kríkos*, a ring). Whence *Crícoïd*, the name of the ring-like cartilage of the larynx. [477.]

CRYS'TALLINE (Gr. *krústallos*, ice). A term applied to the lens of the eye. [376.]

CUBOI'DES (Gr. *kubos*, a cube, and *eīdos*, likeness). The name of a bone of the foot, somewhat *resembling a cube*, situated at the fore and outer part of the tarsus.

CUNEI'FORM (L. *cuneus*, a wedge, and *forma*, likeness). Wedgelike; the name of three bones of the foot.

CU'TICLE (L. dim. of *cutis*). The epidermis, or scarf-skin. [247.]

CU'TIS (Gr. *kútos*, the skin). The true skin, as distinguished from the cuticle, epidermis, or scarf-skin.

D

DEGLUTI'TION (L. *deglutio*, to swallow). The act of swallowing. [156.]

DI'APHRAGM (Gr. *diáphragma*, a partition). The midriff: the transverse muscular partition which separates the thorax from the abdomen. [103.]

DIGES′TION (L. *digero*, from *diversim gero*, to carry into different parts). In *Physiology*, the change of the food into *chyme* by the mouth, stomach, and small intestines; and the absorption and distribution of the more nutritious parts, or the *chyle*, through the system. [133.]

DOR′SUM (Latin). The back; the round part of the back of a man or beast. Whence *Dor′sal*, appertaining to the back, as applied to a region, ligaments, &c. [426.]

DROP′SY (L. *hydrops*, from the Gr. *ùdrōps*, water). An effusion of serous fluid into any of the natural cavities of the body.

DUODE′NUM (L. *duodeni*, twelve). The twelve-inch intestine; so called from its being equal in length to the breadth of twelve fingers; the first portion of the small intestines, beginning from the pylorus. [181.]

DU′RA MA′TER (*hard-mother*). The outermost membrane of the brain. [299.]

DYS′ENTERY (Gr. *dūs*, badly, and *entera*, the bowels). Inflammation of the mucous lining of the large intestines.

DYSPEP′SIA (Gr. *dūs*, and *peptō*, to digest). Indigestion; difficulty of digestion. [171.]

E

EFFLU′VIA (L. *effluo*, to flow out). Exhalations, vapors, &c.

ELASTI′CITY. The property or power by which a body compressed or extended returns to its former state.

ELEVA′TOR (L. *elevo*, to raise). A name applied to certain muscles, whose office it is to elevate any part.

ENAM′EL. The hard exterior surface of the teeth. [146.]

ENCEPH′ALON (Gr. *èn*, in, *kephalē*, the head). The brain; the contents of the skull, consisting of the cerebrum, cerebellum, medulla oblongata, and membranes.

EPIDER′MIS (Gr. *epi*, upon, and *dérma*, the skin). The cuticle, or scarf-skin; the thin horny layer which protects the surface of the integument. [244.]

EPIGLOT′TIS. A cartilage of the larynx, situated above the glottis.

EPIP′LOON (Gr. *plēo*, to sail). The omentum; a membranous expansion which *floats* upon the intestines.

EPITHE′LIUM (Gr. *títhēmi*, to place). The cuticle on the red part of the lips, and on the mucous membranes in general.

ETH′MOID (Gr. *èthmòs*, a sieve, *eīdos*, likeness). Cribriform, or *sieve-like;* a bone of the nose, perforated for the transmission of the olfactory nerves.

EUSTACH′IAN-TUBE. The canal which extends from the tympanum to the pharynx, called after Eustachius, its discoverer. [353.]

EXCRE′TION (L. *excerno*, to separate from). A general term for the perspiration, fæces, &c., which are separated and voided from the blood or the food. [230.]

EXPIRA′TION (L. *expiro*, to breathe). That part of the respiration in which the air is expelled. Compare *Inspiration.*

EXUDA′TION. *Transpiration.* The flow of liquid from the surface of the skin or membrane, an ulcer, &c.

F

Fa'cet. A little face, a small surface.

Fa'cial (L, *facies*, the face). Belonging to the face; as *facial nerve, facial vein*, &c.

Falx. A scythe or sickle. The *sickle*-like processes of the dura mater, situated between the lobes of the cerebrum and cerebellum. [300.]

Fas'cia (L. *fascis*, a bundle). Literally, a scarf or large band. Hence it is applied to the aponeurotic expansion of a muscle.

Fascic'ulus (L. dim. of *fascis*, a bundle). A little bundle; a handful. Thus, a muscle consists of *fasciculi* of fibres. [33.]

Fau'ces. The gullet or upper part of the throat; the space surrounded by the velum palati, the uvula, the tonsils, and the posterior part of the tongue.

Fe'mur, Fem'oris. *Os femoris*. The thigh-bone, the longest, largest, and heaviest of all the bones of the body. [447.]

Fenes'tra (Gr. *phaínō*, to shine). Literally, a window; an entrance into any place. Hence the terms *fenestra ovalis* and *rotunda*, or the oval and round apertures of the internal ear.

Fi'bre (L. *fibra*, a filament). A filament or thread, of animal, vegetable, or mineral composition. [28.]

Fi'bril. A small filament, or fibre, as the ultimate division of a nerve. The term is derived from *fibrilla*, L. dim. of *fibra*, a filament.

Fi'brin. A tough fibrous mass, which, together with albumen, forms the basis of muscle. [49.]

Fi'bro-car'tilage. Membraniform cartilage: a substance intermediate between proper cartilage and ligament. [349.]

Fib'ula. Literally, a clasp, or buckle. It denotes the lesser bone of the leg. [448.]

Fil'ament (L. *filum*, a thread, *forma*, likeness). Thread-like; applied to the papillæ at the edges of the tongue.

Fis'sure. A cleft, a longitudinal opening.

Flex'or (L. *flecto*, to bend). A muscle which bends the part into which it is inserted. Its antagonist is termed *extensor*.

Flu'ids. Substances which have the quality of fluidity, and are, in consequence, of no fixed shape.

Fol'licle (L. dim. of *follis*, a pair of bellows). Literally, a little bag, or scrip of leather; in anatomy, a very minute secreting cavity. [168.]

Fora'men (L. *foro*, to pierce). An opening. [356.]

Fos'sa (L. *fodio*, to dig). A ditch or trench; a little depression, or sinus.

Func'tion (L. *fungor*, to discharge an office). The office of an organ in the animal or vegetable economy, as of the heart in circulation, of the leaf in respiration, &c. [18.]

Fu'siform (L. *fusus*, a spindle, *forma*, likeness). Spindle-shaped; a term applied to certain muscles.

G

GALL'-BLADDER. A membranous reservoir, lodged in a fissure on the under surface of the right lobe of the liver, and containing the bile. [191.]

GALL'DUCTS. These are the *cystic*, proceeding from the gall-bladder; the *hepatic*, proceeding from the liver; and the *ductus communis choledochus*, resulting from the union of the two preceding.

GAN'GLION (Gr. *gangglíon*, a nerve-knot). A small nervous centre, or an enlargement in the course of a nerve, sometimes termed a *diminutive brain*. [262.]

GAS'TER. The Greek term for the stomach.

GAS'TRIC (Gr. *gaster*, the stomach). Pertaining to the stomach; as the gastric juice, &c.

GAS'TRIC JUICE. The peculiar digestive fluid secreted by the stomach. [167.]

GEL'ATINE (L. *gelu*, frost). The principle of jelly. It is found in the skin, cartilages, tendons, membranes, and bones. The purest variety of gelatine is *isinglass*.

GIN'GLYMUS (Gr. *gigglumòs*, a hinge). The *hinge-like* joint; a species of articulation admitting of flexion and extension.

GIZ'ZARD. Of bird. [160.] Insect. [161.]

GLAND (L. *glans, glandis*, an acorn). A soft body, composed of various tissues, vessels, nerves, &c., usually destined to separate some fluids from the blood. [150.]

GLE'NOID (Gr. *glēne*, a cavity, *eīdos*, likeness). The name of a part having a shallow cavity, as the socket of the shoulder-joint.

GLOB'ULES RED (L. dim. of *globus*, a ball). The red coloring matter of the blood; a peculiar animal principle.

GLOS'SA, or GLOT'TA (Gr. *glōtta*). The tongue; the organ of speech.—*Glosso-*. Terms compounded of this word belong to nerves or muscles attached to the tongue.

GLOT'TIS. The aperture of the larynx between the arytænoïd cartilages. It is covered by a cartilage called the *epi-glottis*.

GRAN'ULE. A small particle.

GREAT SYMPATHET'IC. A nerve formed by a collection of filaments from every nerve, which join each other at the adjacent ganglia.

H

HÆM'ATOSIN (Gr. *haima*, blood). A characteristic constituent of the blood, derived from the globules.

HÆM'ORRHAGE. A rupture of a blood-vessel; a bursting forth of blood; loss of blood.

HERBIV'OROUS (L. *herba*, and *vora*). Eating herbs.

HEPAT'IC. A term applied to any part belonging to the liver. [236.]

HEXAG'ONAL. Having six sides and six angles.

HU'MERUS. The bone of the upper-arm. [443.]

HU'MOR (L. *humeo*, to be moist). An aqueous substance; as the humors of the eye.

HY'DRA (Gr. *udor*, water). A polype indigenous in our brooks, destitute of a stomach, brain, viscera, or lungs. [84.]

HY'GIENE (Gr. to be well). Health; the preservation of health; that part of medicine which regards the preservation of health.

HYOI'DES (the Greek letter *upsilon*). A bone situated between the root of the tongue and the larynx.

HYPO-GAS'TRIUM. The lower anterior region of the abdomen.

HYPO-GLOS'SAL. The name of the *lingualis*, or ninth pair of nerves, situated beneath the tongue. [303.]

I, J

ICH'OR. A thin acrid discharge, issuing from wounds, ulcers, &c.

JEJU'NUM (L. *jejunus*, hungry). The upper two-fifths of the small intestines, so named from this portion being generally found *empty*.

IL'EUM (to turn about). The lower three-fifths of the *small intestines*, so called from their convolutions, or peristaltic motions.

IL'IAC-BONE. Another name for the *os innominatum*, derived from the circumstance that this compound bone supports the parts which the ancients called *ilia*, or the flanks.

IL'IAC REGION. The region situated on each side of the hypogastrium.

IN'CUS (*an anvil*). A small bone of the internal ear, with which the malleus is articulated; so named from its fancied resemblance to an anvil.

IN'DEX (L. *indico*, to point out). The fore-finger; the finger usually employed in *pointing* at any object.

INFRA-SPINA'TUS. A muscle arising from the scapula below the spine, and inserted into the humerus.

INNOMINA'TUS (L. *in*, priv., *nomen*, name). Hence *Innominatum os*, a bone composed of three portions, viz: 1, The *ilium*, or haunch-bone. 2, The *ischium*, or hip-bone. 3, The *os pubis*, or share-bone.

INSALIVA'TION. [153.]

IN'STINCT. This convenient term admits of the following significations: 1. The *Instinctive Faculty;* or that faculty which leads the duckling, untaught, into the water; the beaver to build its hut; the bee its comb; the hen to incubate her eggs, &c.; and, 2. The *Instinctive Motions;* or those involuntary actions which are excited mediately through the nerves—a part of the *reflex function*.

INTEG'UMENT (L. *in*, and *tego*, to cover) The covering of any part of the body, as the cuticle, cutis, &c.

INTER-COS'TAL. The name of two sets of muscles between the ribs—the *external* and the *internal*. [104.]

INTES'TINES (L. *intus*, within). That part of the alimentary canal which extends from the stomach to the anus. [183.]

I'RIS. Literally a rainbow; and hence applied to the *rainbow-like* membrane which separates the anterior from the posterior chamber of the eye. [377.]

JU'GULAR. Belonging to the neck; applied chiefly to the principal veins of the neck.

K

KINGDOM. A term denoting any of the principal divisions of nature; thus we have the *organic kingdom*, comprehending substances which organize; and the *inorganic kingdom*, comprehending substances which crystallize.

KNEE'PAN. Patella; the small round bone at the front of the knee-joint.

KID'NEYS. Two oblong glands, which secrete the urine. [235.]

L

LA'BIA. The lips. They are laterally united by means of two acute angles, which are called their *commissures*.

LAB'YRINTH. The name of a series of cavities of the inner ear; viz: the vestibule, the cochlea, and the semi-circular canals.

LACH'RYMA. A tear; the fluid secreted by the *lachrymal gland*, and flowing on the surface of the eye.

LAC'TEALS (L. *lac*, milk). Numerous minute tubes which *absorb* or take up the chyle, or *milk-like* fluid, from the alimentary canal. [188.]

LAC'TIC ACID (L. *lac, lactis*, milk). An acid produced whenever milk, and perhaps most animal fluids, become spontaneously sour.

LAM'INA. Literally, a small plate of any metal. A term applied to the foliated structure of bones or other organs.

LA'RYNX (Gr. *larungx*, the larynx). The superior part of the trachea, situated immediately under the os hyoïdes. [97.]

LENS (L. *lens, lentis*, a bean). Properly, a small roundish glass, shaped like a *lentil*, or bean. [391.]

LIG'AMENT (L. *ligo*, to bind). A membrane of a flexible but compact texture, which connects the articular surfaces of bones and cartilages; and sometimes protects the joints by a capsular envelope.

LIN'GUA (L. *lingo*, to lick). The tongue; the organ of taste and speech.

LIV'ER. The largest glandular apparatus in the body, the office of which is to secrete the bile. [191.]

LOB'ULUS (L. dim. of *lobus*, a lobe). A lobule, or small lobe. [236.]

LUM'BI. The loins; the inferior part of the back; whence *Lumbar*, the designation of nerves, arteries, veins, &c., belonging to the region of the loins.

LUNGS. The organs of respiration. [95.]

LUXA'TION (L. *luxo*, to put out of joint). Dislocation; or the removal of the articular surface of bones out of their proper situation.

LYMPH (L. *lympha*, water). A colourless liquid which circulates in the lymphatics. [22.]

LYMPHAT'ICS (L. *lympha*, water). Minute tubes which pervade every part of the body, which they *absorb*, or take up, in the form of *lymph*. [99.]

M

MAGNE'SIUM. A metal having the color and lustre of silver.

MALLEO'LUS (L. dim. of *malleus*, a mallet). The ankle, so called from its resemblance to a mallet.

MAMMA (L. *mamma*, a teat). The fifth class of the Vertebrata, consisting of animals provided with mammary glands for the suckling of their young after birth.

MAN'DIBLES. The jaws of a bird.

MAS'SETER (Gr. to chew). A muscle which assists in chewing.

MAS'TOID (Gr. a breast). Shaped like the breast or nipple; as applied to a *process*, and a *foramen* of the temporal-bone.

MEA'TUS (L. *meo*, to pass, to flow). Literally, a passage.

MEDUL'LA. Marrow; a kind of fixed oil, occupying the cavities of bones. [2.]

MEDUL'LA OBLONGATA. The upper enlarged portion of the spinal cord. [291.]

MEDUL'LA SPINALIS. The spinal marrow or cord.

MEDUL'LARY. The designation of the *white* substance of the brain. [339.]

MES'ENTERY (Gr. between the bowels). The membrane which connects the small intestines and the posterior wall of the abdomen.

META-CAR'PUS (Gr. after, the wrist). That part of the hand which is situated between the carpus and the fingers.

META-TAR'SUS. That part of the foot which is situated between the tarsus and the toes. [250.]

MID'RIFF. *Diaphragm.* The muscle which divides the body into the thorax and the abdomen.

MI'TRAL VALVES (L. *mitra*, a mitre). The name of two valves which guard the left ventricle of the heart.

MO'LAR (L. *mola*, a mill-stone). The double or grinding teeth. Those with two fangs are called bicuspid, or false molars.

MOL'LUSCS. Animals without an internal skeleton or articulated covering.

MO'TOR (L. *moveo*, to move). A mover; a part whose function is *motion*.

MU'CUS. The liquid secreted by the mucous surfaces, as of the nostrils, intended as a protection to the parts exposed to external influences.

N

NARCOT'ICS (Gr. stupor). Medicines which induce sleep or stupor, as opiates

NA'SUS. The nose, or organ of smell; whence *nasal*, belonging to the nose. [333.]

NERVES (L. *nervus*, a string). White cords arising from the brain or the spinal marrow, and distributed to every part of the system. [250.]

NEURAL'GIA. Nerve-ache, or pain in the nerve.

NEU'RON (Gr.). A nerve; a cord arising from the brain or spinal marrow, whence *Neurilemma*, the sheath of a nerve and *Neurology*, the doctrine of the nerves.

NIC'TATING. Winking.

NI'TROGEN. *Azote.* An elementary principle, constituting four-fifths of the volume of atmospheric air.

NU'CLEUS. The kernel of a nut. The centre around which particles are aggregated.

NUTRI'TION (L. *nutrio*, to nourish). The process of nourishing the frame. [16–218.]

O

OBLI'QUUS. Oblique or slanting; not direct, perpendicular or parallel, applied to several muscles.

OBTURA'TOR (L. *obturo*, to stop up). The name of two muscles of the thigh, and of a nerve.

OC'CIPUT (L. *ob caput*). The back part of the head; the part *opposite* to the front or *sinciput*.

ŒSOPH'AGUS (Gr. to carry, to eat). A cana. eading from the mouth to the stomach. [153.]

OLEAG'INOUS (L. *oleum*, oil). That which contains, or resembles, oil.

OLEC'RANON. The large *apophysis*, constituting the elbow, or head of the ulna.

OLFAC'TORY (L. *olfacio*, to smell). Belonging to the smell; the name of the first pair of cerebral nerves, &c. [282.]

OMEN'TUM. The caul; a fold or reflexion of the peritoneum.

OMO (Gr. the shoulder). Words compounded with this term belong to muscles attached to the scapula.

OP'TIC. Belonging to the sight. [281.]

ORBICULA'RIS. The name of two muscles of the face.

OR'BIT (L. *orbita*, an orbit, a track). The cavity under the forehead, in which the eye is fixed. [370.]

OR'GAN. A part which has a determinate office in the animal economy. [36.]

ORGANIZA'TION. A term applied to a system, composed of several individual parts, each of which has its proper function, but all conduce to the existence of the entire system.

OR'IGIN (L. *origo*). The commencement of a muscle from any part. Its attachment to the part it moves is called its *insertion*.

OS, OSSIS. A bone; a portion of the skeleton, constituting a *passive* organ of locomotion, as distinguished from a muscle, or *active* organ of this faculty.

OSSIFICA'TION. The formation of bone; the deposition of calcarious phosphate, or carbonate, on the soft solids of animal bodies.

OT'OLITES (Gr. the ear, a stone). Calcarious concretions found in the labyrinth of fishes and fish-like amphibia, which, by being in contact with the membranous parts of the labyrinth, increase by their resonance the sonorous vibrations.

OX'IDES. Substances combined with oxygen, without being in the state of an acid.

OX'YGEN. A gas which forms about a fifth of atmospheric air, is capable of supporting flame, and is essential to the respiration of animals.

P

PAN'CREAS. A gland, situated transversely across the posterior wall of the abdomen. In cattle it is called the *sweet-bread*. [189.]

PANCREAT'IC JUICE. The peculiar fluid secreted by the pancreas. [163.]

PAPIL'LA. The term *papillæ* denotes the small eminences which constitute the roughness of the upper surface of the tongue. [27.]

PARAL'YSIS. Palsy; the total loss, or diminution, of sensation or of motion or of both.

PAROT'ID. The name of the large salivary gland situated near the ear. [153.]

PAR'IES, PARI'ETIS. The wall of a house, or any other building; whence *Parietal*, belonging to the walls of an organ.

PATEL'LA (L. dim. of *patina*, a pan). Literally, a small pan. The knee-pan.

PATHET'IC (Gr. *passion*). A name given by Willis to the fourth pair of nerves, because the eyes, by means of these, express certain passions. [303.]

PEC'TORAL (L. *pectus*, the breast). Pertaining to the breast.

PECTORAL'IS. The name of two muscles of the trunk.

PE'DAL (L. *pedules*). Pertaining to a foot.

PEL'VIS (Gr. *a basin*). The basin, or large bony cavity which terminates the trunk inferiorly. [110.]

PERICAR'DIUM (Gr. *around the heart*). A fibro-serous membrane which surrounds the heart. [61.]

PERICRA'NIUM. The periosteum or membrane which covers the bones of the cranium.

PERIOS'TEUM. The membrane which surrounds the bones.

PERISTAL'TIC. A term applied to the vermicular contractions of the intestines upon themselves.

PERITONÆ'UM. The serous membrane which lines the interior of the abdomen, and invests all the viscera contained therein.

PERMEABIL'ITY (L. *per*, through, *meo*, to pass). That property of certain bodies by which they admit the passage of other bodies through their substance.

PERSPIRA'TION (L. *perspiro*, to breathe through). The watery vapor which is constantly passing off through the skin. [254.]

PHA'LANX. A battalion in the Macedonian armies, composed of 16,000 men. Hence the term *phalanges* is applied to the bones of the fingers and toes, from their regularity.

PHA'RYNX (Gr. *the throat*). A musculo-membranous bag, situated at the back part of the mouth, leading to the stomach.

PHRE'NES (Gr. *the mind*). The diaphragm; so called because the ancients supposed it to be the seat of the mind. Hence the term *Phrenic*, a designation of the internal respiratory nerve, which goes to the diaphragm.

PHRENOL'OGY (Gr. *an account*). A description of the mind; a science, introduced by Gall and Spurzheim, by which particular characters and propensities are indicated by the conformation, and protuberances, of the skull.

PHYSIOL'OGY (Gr. *phusis*, nature, *logos*, an account). The science which treats of the properties of organic bodies, animal and vegetable, of the phenomena which they present, and of the laws which govern their actions. [8.]

PI'A MA'TER. A vascular membrane, investing the whole surface of the brain. [299.]

PIGMEN'TUM NI'GRUM (L. *pingo*, to paint). A dark brown substance, which covers the outer and inner surface of the choroïd membrane.

PIN'NA. The fin of a fish. A portion of the external ear, termed *pinna auriculæ*, or the auricle, representing a kind of funnel, which collects the vibrations of the atmosphere. The other portion is termed *meatus*, and represents a tube, which conveys the vibration to the tympanum.

PITU'ITARY MEMBRANE. A designation of the Schneiderian membrane, which lines the cavities of the nose.

PLEU'RA. [106.]

PLEX'US (L. *plecto*, to weave). A kind of net-work of blood-vessels, or nerves.

PLANA'RIA. [157.]

PNEU'MO-GAS'TRIC NERVES (Gr. *pneumōn*, the lung, *gastér*, the stomach). The par vagnum, nervi vagi, or eighth pair of nerves, distributed to the stomach.

POL'YPE. A species of fresh-water insect. [136.]

POR'TAL CIRCULA'TION. A subordinate part of the venous circulation, in which the blood makes an additional circuit before it joins the rest of the venous blood.

POR'TAL VEIN (L. *vena portæ*). A vein originating from the organs within the abdomen. [46.]

POR'TIO DU'RA. The *hard portion* of the seventh pair of nerves, or *facial*. [303.]

POR'TIO MOL'LIS. The *soft portion* of the seventh pair of nerves, or *auditory*. [303.]

POTAS'SIUM. The metallic base of the well-known alkaline substance potassa.

PREHEN'SION. A taking hold, a seizing.

PRISM (Gr. *prisma*, from *prio*, to saw). A solid glass in the form of a triangle, so termed from its *separating* a ray of light into its constituent parts.

PRO'CESS. *Apophysis*. A process, or eminence of a bone. Also, a lobe, or portion of the brain.

PRONA'TION (L. *pronus*, bending downward). The act of turning the palm of the hand downwards, by rotating the radius upon the ulna by means of the pronator muscles.

PRONA'TOR (L. *pronus*, bending downward). The name of two muscles which turn the radius and the hand inwards and downwards.

PROX'IMATE PRIN'CIPLE. A term applied, in analyzing any body, to the principle which is *nearest* to the natural constitution of the body, and more immediately the object of sense, as distinguished from intermediate or ultimate principles. *Ultimate principles* are the elements of which proximate principles are composed.

PSO'AS (Gr. *psóai*, the loins). The name of two muscles of the loins.

PUL'MONARY, *pulmonic*, (L. *pulmo*, the lungs). Relating or belonging to the lungs.

PULSE (L. *pulsus*, a stroke). A beating or striking; and, hence, the stroke or beat of an artery. [69.]

PUNC'TUM (L. *pungo*, to prick). A point; that which is without extent.

PUNC'TA LACHRYMA'LIA. The external commencements of the lacrymal ducts

PU'PILA (L. dim. of *pupa*, a puppet). The pupil, or the round aperture in the centre of the iris of the eye. [384.]

PYLO'RUS (Gr. *púle*, a gate; *ōra*, care). Literally, a *gate-keeper*. The lower and contracted orifice of the stomach, guarding the entrance into the bowels.

Q

QUARTZ. A species of silicious minerals.

R

RAM'IFICATION (L. *ramus*, a branch, *fio*, to become). The issuing of a small branch from a large one, as of the minute branches from the larger arteries.

RA'MUS. A branch of a tree; the designation of portions of several bones.

REC'TUM (L. *rectus*, straight). The last portion of the intestines.

REC'TUS (L. *straight*). The name of several muscles.

REFRAC'TION (L. *refractus*, broken back). That property of light, by which a ray becomes bent, or *refracted*, when passing from a rarer into a denser medium, and *vice versâ*. [389.]

RESPIRA'TION. The function of breathing.

RET'INA (L. *rete*, a net). The *net*-like expansion of the optic nerve on the inner surface of the eye. [271.]

RI'MA. A fissure, a crack, or cleft; a narrow longitudinal opening.

RODEN'TIA (L. *rodo*, to gnaw). Glires, or gnawing animals, as the beaver, the hamster, the rat, &c.

RU'GA. A wrinkle. Hence the terms *rugose*, wrinkled, and *rugosity*, applied to a wrinkled surface, as the mucous membrane of the stomach.

RUMINAN'TIA (L. *rumino*, to chew the cud). Animals which chew the cud, as the deer.

RUMINA'TION. A voluntary regurgitation of food for further mastication; peculiar to the ox, sheep, and other animals having numerous stomachs; it is commonly called *chewing the cud*. [159.]

S

SAC (L. *saccus*, a bag). A term applied to a small cavity, as the lacrymal sac. [90.]

SA'CRUM (L. *Sacred*). The bone which forms the basis of the vertebral column, so called from its having been offered in sacrifice, and hence considered *sacred*. [426.]

SACRO-. A term applied to parts connected with the sacrum; hence we have *sacro*-iliac symphysis, *sacro*-spinal ligament, *sacro*-vertebral angle, &c.

SALI'VA. The insipid, transparent, viscous liquid, secreted by the salivary glands, principally the parotid. [153.]

SAN'GUIS. Blood; the fluid which circulates in the heart, arteries, and veins.

SARTO'RIUS (L. *sartor*, a tailor). The muscle by means of which the tailor crosses his legs.

SCAP'ULA. The shoulder-blade.

SCHNEIDE'RIAN MEMBRANE. The *pituitary membrane*, which secretes the mucous of the nose; so named from Schneider, who first described it. [337.]

SCIAT'IC NERVE. The termination of the sacral or sciatic plexus; it is the largest of all the nerves.

SCLEROT'ICA (Gr. *sklērŏs*, hard). The dense fibrous membrane which, with the *cornea*, forms the external tunic of the eye-ball.

SEBA'CEOUS (L. *sebum*, suet). Suety; a term applied to *follicles* which secrete a peculiar oily matter, and are abundant in some parts of the skin, as in the nose, &c. [257.]

SECRE'TION (L. *secerno*, to separate). A substance *secreted* or separated from the blood, by the action of a secreting organ. [31.]

SEG'MENT. A part cut off or divided.

SEP'TUM (L. *sepes*, a hedge). A partition which separates two cavities.

SERRA'TUS (L. *serra*, a saw). The name of three muscles of the side and back

SE'RUM. The thin yellowish fluid constituent of the blood. [45.]

SIN'CIPUT. The fore part of the head. The back part is called *occiput*.

SIN'EW. The ligament which joins two bones.

SI'NUS. A gulf. Hence it denotes a cavity or cell within the substance of a bone, as of the forehead; also a large venous canal, as those of the dura mater.

SKEL'ETON (Gr. *skéllō*, to dry up). The dry bony frame-work of an animal which sustains the other organs.

SPHINC'TER (L. *sphínggo*, to contract). A muscle, whose office it is to close the aperture around which it is placed. [181.]

SPI'NAL CORD. *Medulla spinalis.* The medullary matter contained within the *spine*, or vertebral column. [263.]

SPLEEN A spongy organ, situated at the left and behind the stomach.

SPLINT'BONE. The fibula, or small bone of the leg; so named from its resembling a surgical splint.

STA'PES. Literally, a stirrup. A stirrup-like bone of the internal ear. [356.]

STER'NUM. The breast-bone. [438.]

STIGMA'TA. The apertures in the bodies of insects communicating with the tracheæ or air-vessels.

STOM'ACH of the Hydra. [157.]
" Planaria. [157.]
" Sheep. [159.]
" Bird. [160.]
" Man. [163.]

STU'POR (L. *stupeo*, to be senseless). A state of insensibility.

STY (L. *stihan*, Saxon, a springing up). *Stian.* A little inflammatory tumor on the eye-lid.

SUB-. A Latin preposition, denoting a position *beneath* any body.

SUB-CLA'VIAN. Situated under the clavicle.

SUB-CLA'VIUS. A muscle arising from the cartilage of the first rib, and inserted into the lower surface of the clavicle.

SUB-CUTAN'EOUS. Beneath the skin.

SUB-LIN'GUAL. Beneath the tongue.

SUB-MAX'ILLARY. Beneath the jaw.

SU'DOR (L. *sudo*, to sweat). Sweat; the vapor which passes through the skin, and condenses on the surface of the body.

SUDORIF'EROUS CANALS. Minute spiral follicles, distributed over the whole surface of the skin, for the secretion of the sweat.

SU'TURE (L. *suo*, to sew). A seam; the junction of the bones of the cranium by a serrated line, resembling the stitches of a seam.

SYMPATHET'IC NERVE. A nerve consisting of a chain of ganglia, extending along the side of the vertebral column from the head to the coccyx, communicating with all the other nerves of the body, and supposed to produce a *sympathy* between the affections of different parts.

SYNO'VIA (Gr. *ōòn*, an egg). A peculiar liquid, found within the capsular ligaments of the joints, which it lubricates.

T

TAR'SUS. The instep; the space between the bones of the leg and the metatarsus. [450.]

TEARS. The peculiar fluid which lubricates the eye.

TEETH. [143.]

TEM'PORA (L. pl. of *tempus*, time). The temples, or that part of the head on which the hair generally begins to turn gray, thus indicating *the age;* whence *temporal*, pertaining to the temples, as temporal bones.

TENA'CITY (L. *teneo*, to hold). The degree of force with which the particles of bodies cohere, or are held together.

TEN'DON (L. *téinō*, to stretch). A fibrous cord at the extremity of a muscle, by which the muscle is attached to a bone.

TEN'SOR (L. *tendo*, to stretch). A muscle which *stretches* any part.

TENTAC'ULA. A filliform process or organ on the bodies of various animals.

TENTO'RIUM (L. *tendo*, to stretch). A tent, or pavilion, as *Tentorium cerebelli*, a roof of dura mater thrown across the cerebellum. In leaping animals, it is a bony substance.

THO'RAX (Gr. *thórax*). The chest; or that cavity of the body which contains the heart and lungs. [60.]

THORA'CIC DUCT. The great trunk formed by the junction of the absorbent vessels. [209.]

THY'ROID (Gr. *thureòs*, a shield). The name given to a shield-shaped cartilage of the larynx, and of a gland situated on the trachea.

TIB'IA. Literally, a flute or pipe. The shin-bone; or the great bone of the leg.

TIB'IAL, *tibialis*, pertaining to the tibia.

TIS'SUE. A web, or web-like structure, constituting the elementary structures of animals and plants. [17.]

TON'SILS (L. *tondeo*, to clip, or shear). The round glands situated in the throat, between the pillars of the velum palati.

TRACH'EA (Gr. *trachus*, rough). The wind-pipe. The term is derived from the inequality of its cartilages. [99.]

TRACT (L. *traho*, to draw). A drawing in length; a region; a space.

TRI'CEPS. Having three heads. Applied to several muscles.

TRICUS'PID. Having three points; a term applied to three triangular folds or *valves* situated between the right auricle and the right ventricle of the heart. [63.]

TRIFA'CIAL. Triple-facial; a term applied to the fifth pair of nerves, the grand sensitive nerve of the head and face.

TROCHAN'TER (Gr. *trocháō*, to run or roll). The name of two processes of the thigh-bone—the *major* and the *minor*.

TROCH'LEA (Gr. *tróchos*, a wheel). A kind of cartilaginous pulley. Hence *Trochlearis*, a name of the obliquus superior, or that muscle of the eye which passes through the *trochlea* or pulley. [387.]

TU'NIC. The upper garment of the Romans. Hence it is applied to several membranes of the body.

TUR'BINATED BONES (L. *turbo*, a top). Two bones of the nostrils, so called from their being formed in the shape of a top, or inverted cone. They are also called the *inferior spongy bones*, to distinguish them from the upper spongy bones.

TYM'PANUM (Gr. *túmpanon*, a drum). The drum of the ear. [351.]

U

UL'NA (Gr. *ōlénē*, the cubit). The large bone of the fore-arm, so named from its being often used as a measure, under the term *ell*. [143.]

UVE'A (L. *uva*, grape). The posterior surface of the iris, so called from its resemblance in colour to a ripe grape.

U'VULA (L. dim. of *uva*, a grape). The pendulous body which hangs down from the middle of the soft palate.

V

VACCINA'TION (L. *vacca*, a cow). The act of inserting vaccine matter; inoculation for the cow-pox.

VAC'UUM (L. *vaccus*, empty). Literally, an empty place. This term generally denotes the interior of a close vessel, from which the atmospheric air and every other gas has been extracted.

VALVE (L. *valvæ*, folding-doors). A close lid affixed to a tube or opening in some vessel, by means of a hinge, or other movable joint, and which can be opened only in one direction. Hence it signifies a little membrane which prevents the return of fluid in the blood-vessels and absorbents.

VAL'VULA (L. dim. of *valve*). A little valve.

VAS, VASIS. Plural *Vasa*. A vessel, or any utensil to hold liquor.

VAS'CULAR SYSTEM. That part of the animal economy which relates to the vessels.

VE'NOUS. Belonging to a vein. [75.]

VENTRIC'ULUS (L. dim. of *venter*, the belly). The term *ventricle* is also applied to two cavities of the heart, and to several cavities in other parts of the body.

VER'MIFORM (L. *vermis*, a worm, *forma*, likeness). Worm-like.

VERMIC′ULA. Having a worm-like motion.

VER′TEBRA (L. *verto*, to turn). A bone of the spine, so named from its *turning* upon the adjoining one. [286.]

VER′TEBRAL. Connected with the vertebra.

VERTEBRA′TA. Animals which have an internal skeleton, supported by a vertebral column. [281.]

VES′SICLE (L. dim. of *vesica*, a bladder). A little bladder.

VES′TIBULE (L. *vestibulum*, a threshhold). A small oval cavity of the internal ear, so named from its forming an entry to the cochlea and semi-circular canals. [46.]

VILL′US. Literally, the shaggy hair of beasts. Some of the membranes of the body, as the mucous membrane of the intestinal canal, present a surface of minute papillæ, termed *villi*, villosities, resembling a downy tissue, continually covered with fluid.

VIT′REOUS BODY (L. *vitrum*, glass). *Vitreous humour.* A transparent mass, resembling melted glass, occupying the globe of the eye, and inclosed in the hyaloïd membrane. [376.]

VOICE. [471.]

W

WARM-BLOODED. A term applied to the mammalia and birds which have a two-fold circulation. [128.]

X

XYPH′OID (Gr. *xíphos*, a sword, *eìdos*, likeness). Sword-like; a term applied to the cartilage of the sternum.

Z

ZOŌL′OGY (Gr. *zoōn*, an animal, *lógos*, a description). That branch of Natural History which treats of animals.

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